NCHRP 20-27(3) Multi-Modal Transportation LRS Data Model and Implementation Guidelines

GIS-T 2001

Arlington, VA
April 9-11, 2001

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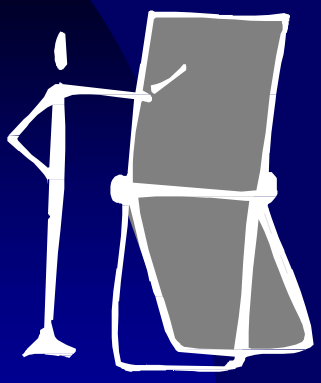
Presentation Outline



- Introduction & Background
- Significant Aspects of the MDLRS Data Model
- Future Steps & Conclusions

Acknowledgements

Investigators

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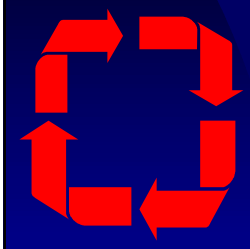
Research Plan

- Establish community consensus on the functional requirements for a Multi-dimensional Location Referencing System (LRS) data model.
- Develop a MDLRS data model that meets the functional requirements.
- Develop guidelines for implementing the MDLRS data model

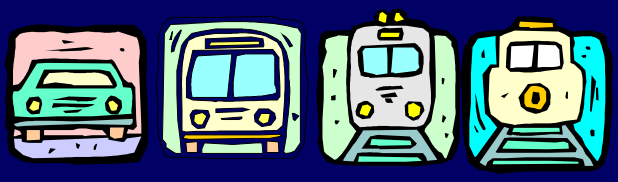
Support for Interoperability



The MDLRS data model ...

- is based on existing geo-spatial standards and models
- is application independent
- condenses the 'world' into aspatial, spatial, temporal and process data
- uses object-level metadata

Scope



- Ground-Based Transportation Systems
- Multi-Modal
- Multi-Dimensional (3D + Time)
- Functional Requirements based on Stakeholder's Workshop

Milestones Timeline

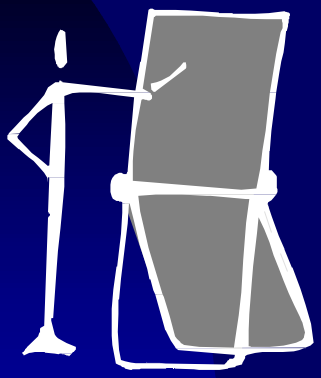
GIS-T ‘98	Identify Issues
Dec. ‘98	Stakeholder’s Workshop
April ‘99	Web Review of Functional Requirements
GIS-T ‘99	Synthesis Results
GIS-T ‘00	Temporal Modeling Constructs
Feb. ‘01	Web Review of Draft Report
April ‘01	Final Report
GIS-T ‘01	User Forum

Motivation

Functional Requirements for Multi-Dimensional Data:

- Spatial / Temporal Referencing Methods
- Temporal Referencing System / Temporal Datum
- Transformation of Data Sets
- Multiple Cartographic / Spatial Topological Representations (Multi-scale)
- Resolution (Granularity)
- Dynamics
- Historical Databases
- Accuracy & Error Propagation
- Object-Level Metadata
- Temporal Topology / Latency

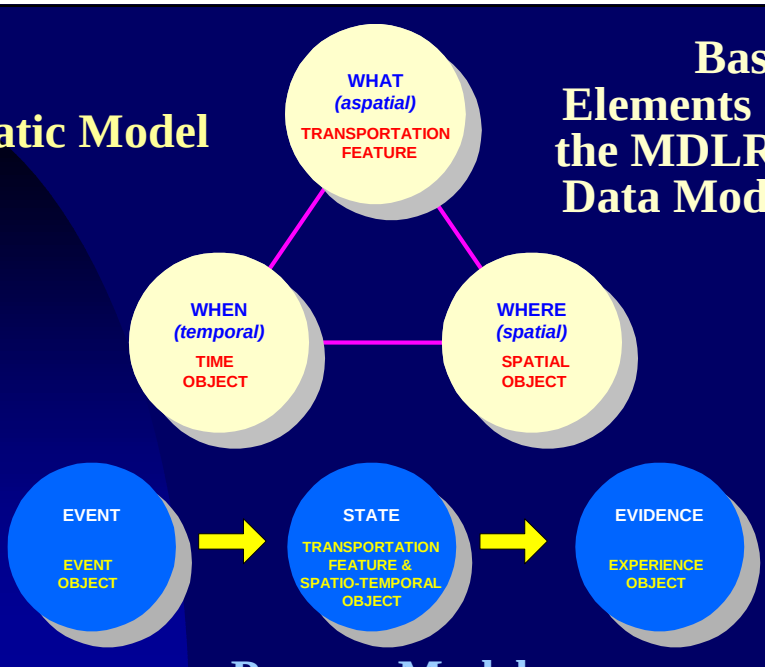
Presentation Outline



- Introduction & Background
- Significant Aspects of the MDLRS Data Model
- Future Steps & Conclusions

Basic Elements of the MDLRS Data Model

Static Model



Process Model

Significant Aspects of the MDLRS Data Model

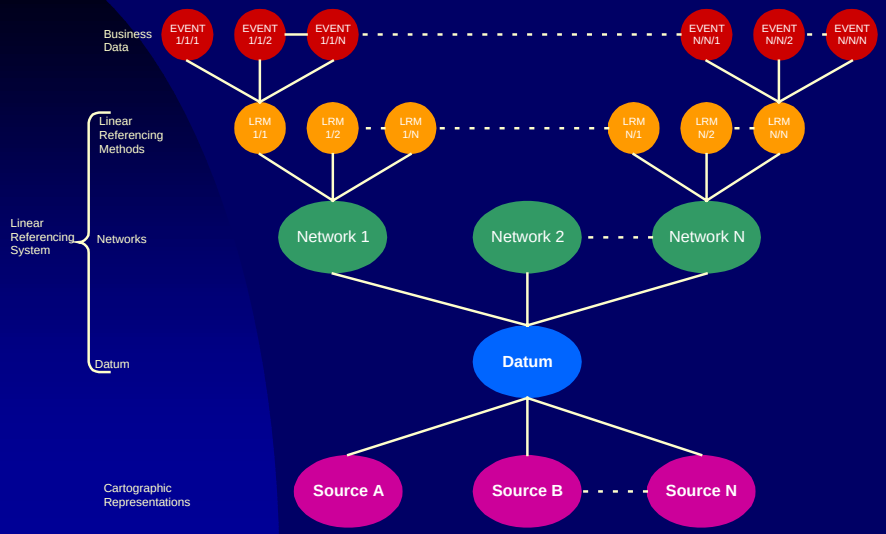
Multi-dimensional Location Referencing

Multi-scale Representations

Navigation

Temporal GIS-T

Integration of Linearly Referenced Data NCHRP 20-27(2)

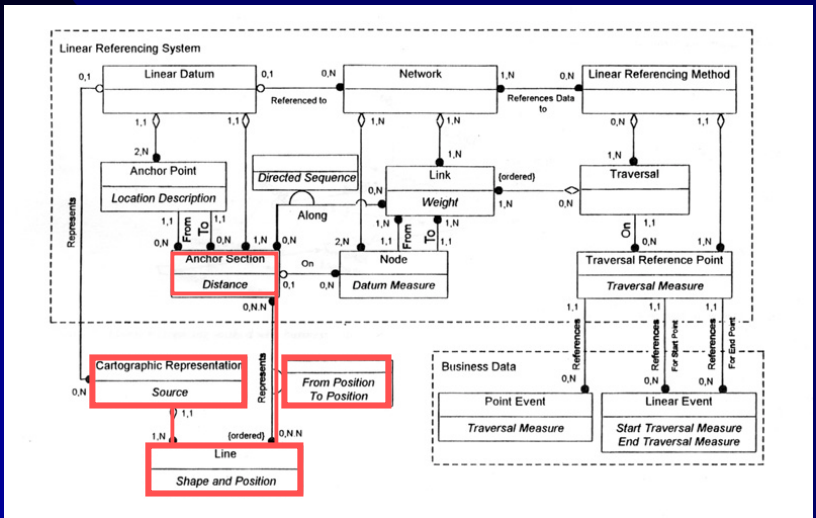


Integration of Multi-Dimensional Referenced Data

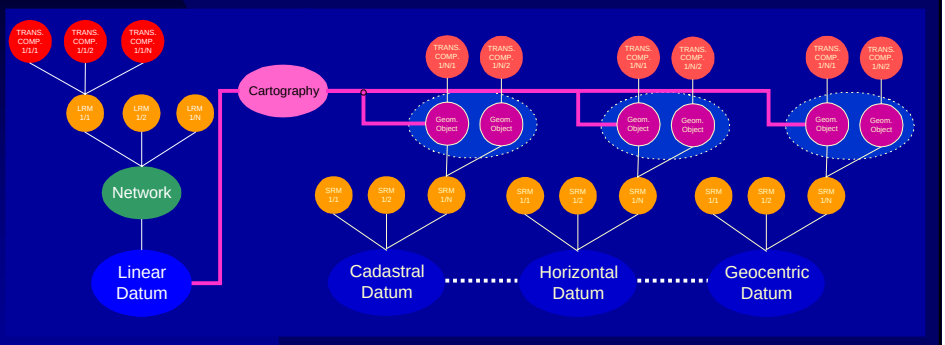
Problem Statement

- Transportation Agencies manage and share multi-dimensional data
- No framework is available to integrate and effectively use data across dimensions and referencing systems
- Major goal of NCHRP 20-27(3)

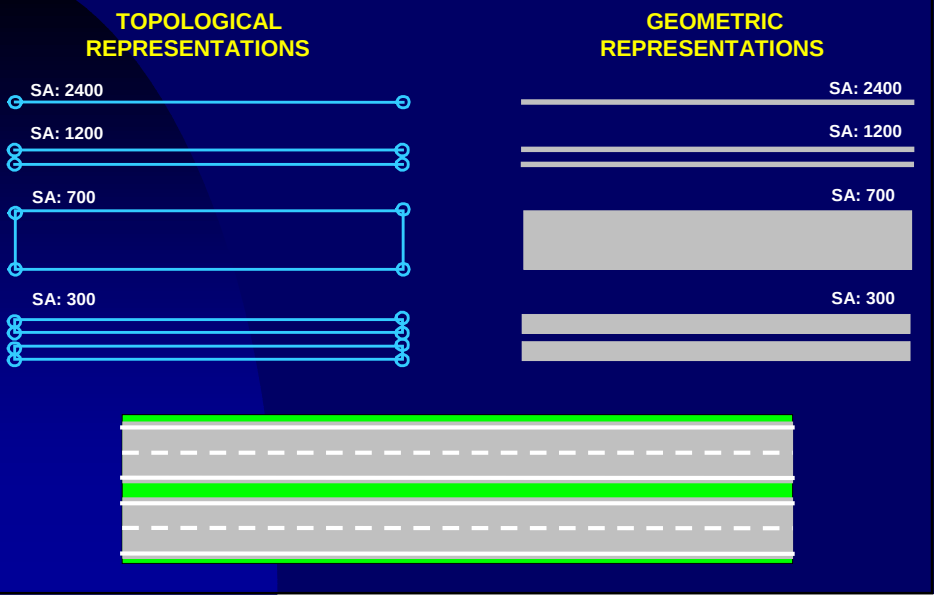
Integration of Multi-Dimensionally Referenced Data (NCHRP 20-27(2))

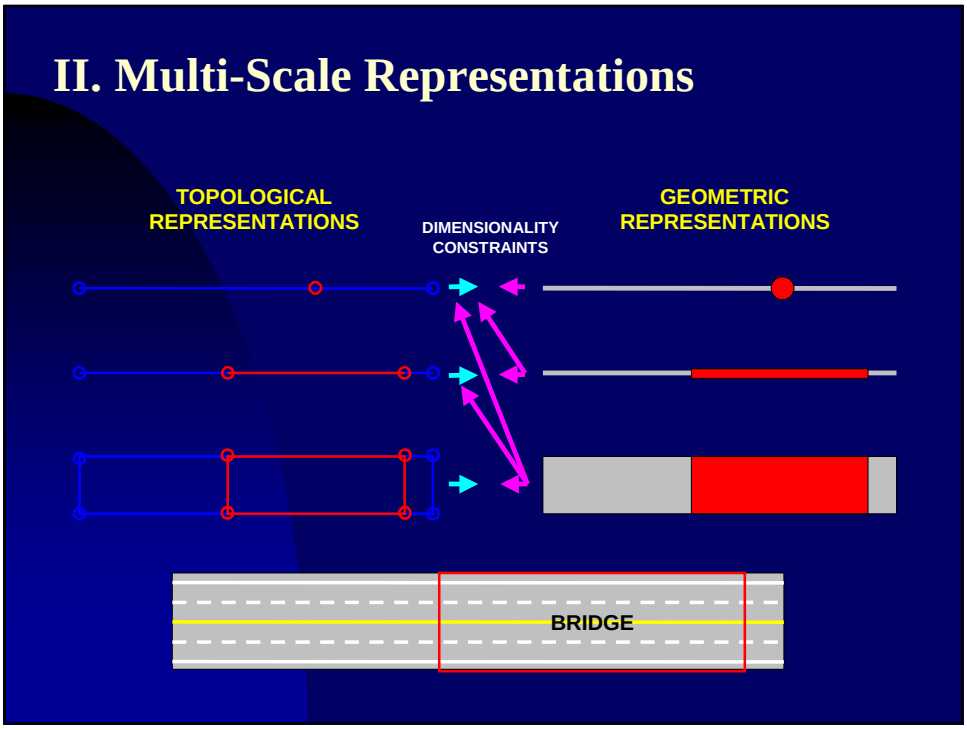


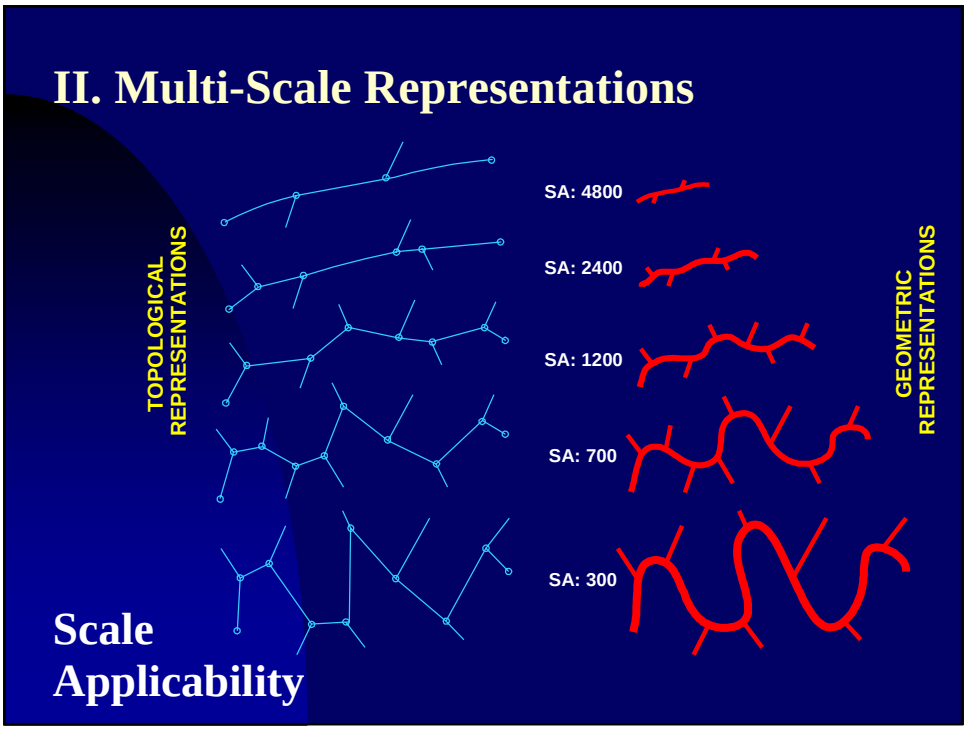
Integration of Multi-Dimensionally Referenced Data (NCHRP 20-27(3))



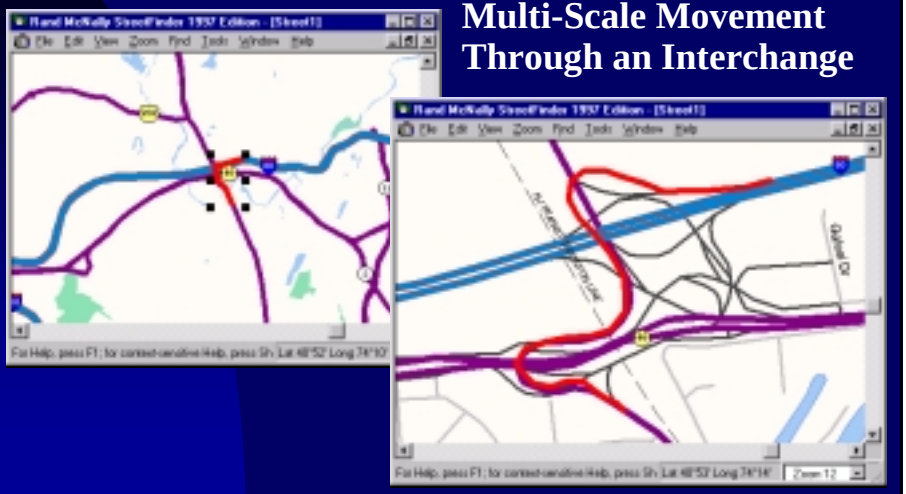
II. Multi-Scale Representations




II. Multi-Scale Representations
TOPOLOGICAL REPRESENTATIONS
DIMENSIONALITY CONSTRAINTS
GEOMETRIC REPRESENTATIONS
BRIDGE

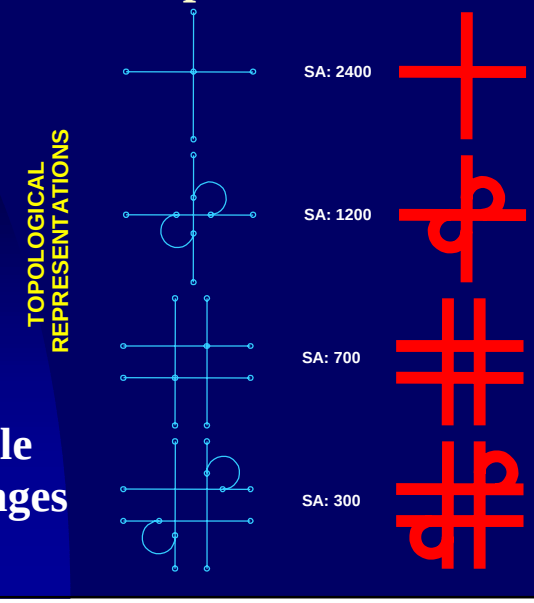

II. Multi-Scale Representations
TOPOLOGICAL REPRESENTATIONS
SA: 4800
SA: 2400
SA: 1200
SA: 700
SA: 300
GEOMETRIC REPRESENTATIONS
Scale Applicability

II. Multi-Scale Representations



Multi-Scale Movement Through an Interchange

II. Multi-Scale Representations



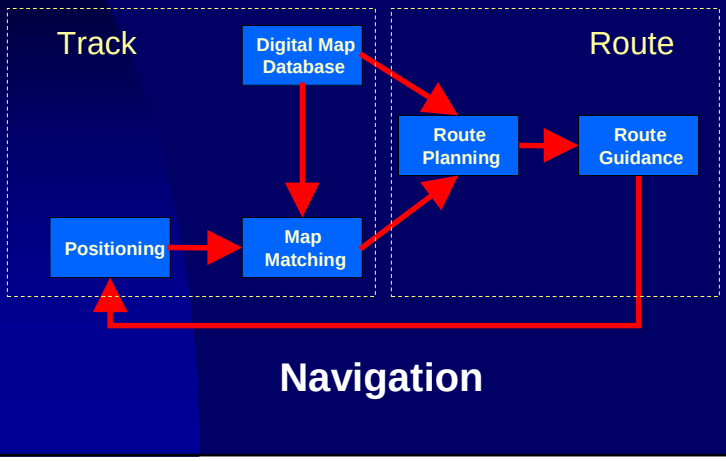
Multi-scale Interchanges

III. Support for Navigation

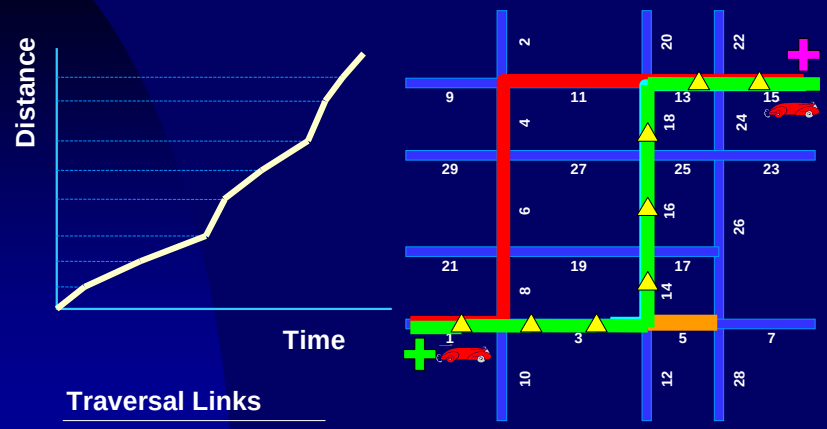
- Navigation requires the modeling of ‘dynamic objects’ or ‘conveyances’ interacting with an environment that is constantly changing
- All objects and their attributes need to be time-dependent (i.e. validity period)
- Time-dependency allows temporal reasoning

III. Support for Navigation

Relationship between Track, Route and Navigate



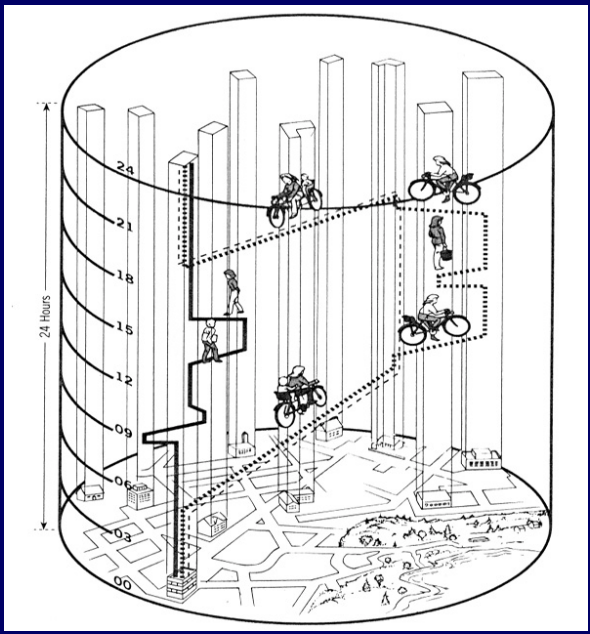
III. Support for Navigation



Traversal Links

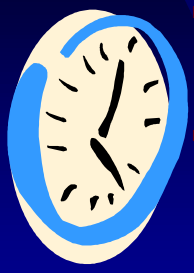
1, 3, -14, -16, -18, 13, 15

How do you view a temporal GIS?



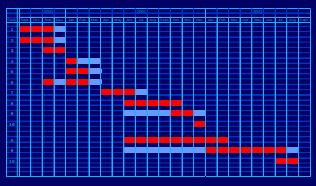
after Parkes and Thrift (1980)

IV. Temporal GIS-T



- GIS assumes a static world
- Necessity for incorporating the time dimension (Barrera et al 1991; Egenhofer and Golledge 1994; Langran1989, 1992; Worboys, 1995, etc.)
- The MDLRS data model accommodates the temporal element through:
  - Storage
  - Referencing
  - Relationships
  - Histories

IV. Temporal GIS-T



Storage of the Temporal Element

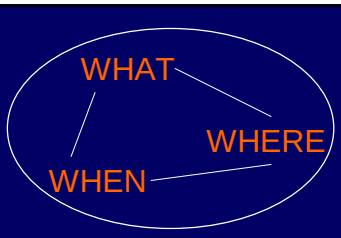
- Use of a "TimeObject" that can accommodate
  - Absolute Time (e.g. 9:00 am 3/1/01)
  - Relative Time (e.g. 1 week from today)
  - Duration (e.g. 1 hr)
  - Multi-dimensional Time (e.g. cycles, stages)
  - Transaction Time (i.e. time recorded in a DB)

IV. Temporal GIS-T

Referencing of the Temporal Element

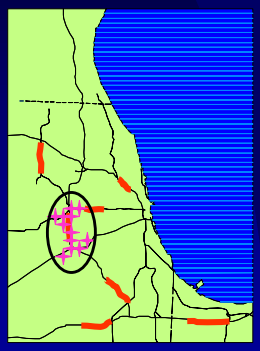
- Use of Temporal Referencing Methods/Datum that can accommodate:
  - Time offsets (e.g. zonal time)
  - Calendar offsets (e.g. fiscal year)
  - Calendar metrics (e.g. Jewish calendar)
  - Time metrics (e.g. Julian date)
  - Temporal systems (e.g. interval, ordinal)

IV. Temporal GIS-T



Temporal Relationships

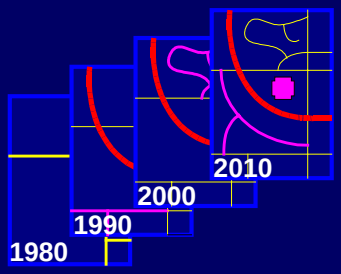
- Use of Temporal Topology constructs allow:



  - **Spatial / temporal proximity** (e.g. prevent road striping before paving.)
  - **Temporal within** (e.g. identify all projects being let in the third quarter of the year.)
  - **Spatial / temporal within** (e.g. all accidents during a construction project within a construction boundary.)
  - **Temporal after** (e.g. all accidents that occur after a project completion.)

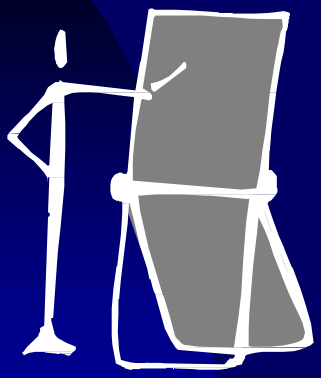
IV. Temporal TGIS

Historical Database



- Use of "Experience" objects allow:
  - **Simple Spatio-temporal queries** (e.g. state of an object, network, system at time t?)
  - **Spatio-temporal range queries** (e.g. changes of an object, network, system over a given period?)
  - **Exploration** (e.g. patterns of change over time?)
  - **Prediction** (e.g. what changes may occur over time?)
  - **Planning** (e.g. optimal allowable changes over time?)

Presentation Outline



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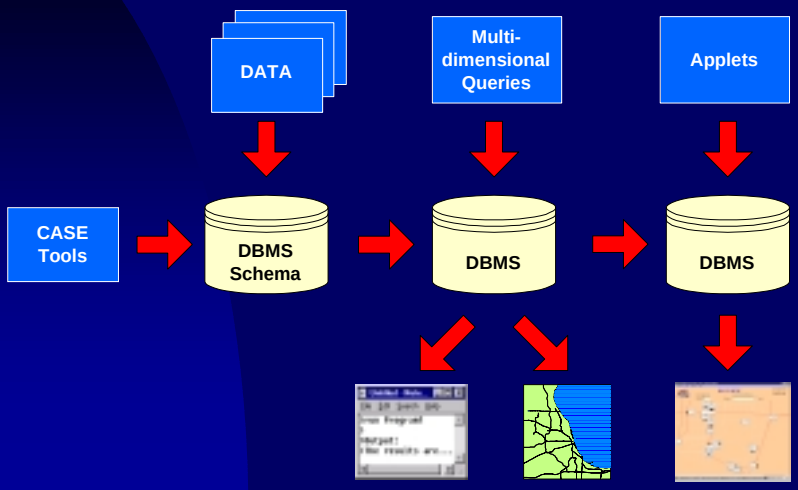
- Future Steps & Conclusions

Future Research

- Testing of the MDLRS data model



Conclusion

The MDLRS data model ...

- represents the “next” step in transportation-based LRS research
- is based on functional requirements established by community consensus
- supports multi-dimensional / multi-representational data
- can be considered a true temporal GIS-T model

Implementing a NCHRP 20-27(3) linear referencing system for Virginia DOT

Graham Stickler, V-P exor corporation,

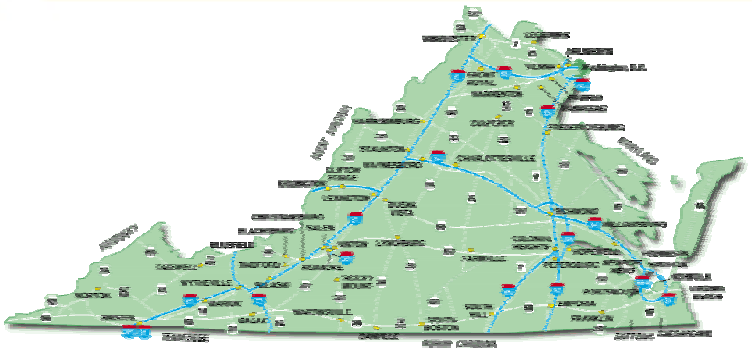
& Dan Widner, GIS Manager, VDOT

Paper # 1.1.2, GIS-T, April 2001

Content

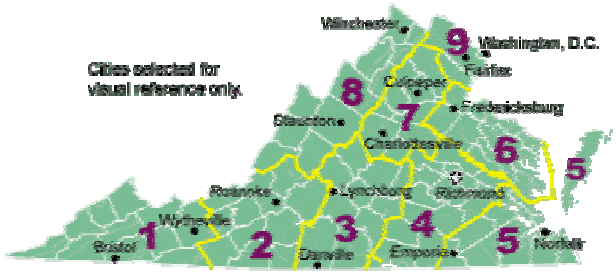
- VDOT
- Exor Corporation
- Project Overview
- Data sources
- LRS model
- Software
- Progress
- Conclusions

Virginia DOT



- Differentiator in that DOT manages most County's roads
- 70,328 Public Road Mileage (1999)
- 56,595 VDOT maintained centerline miles

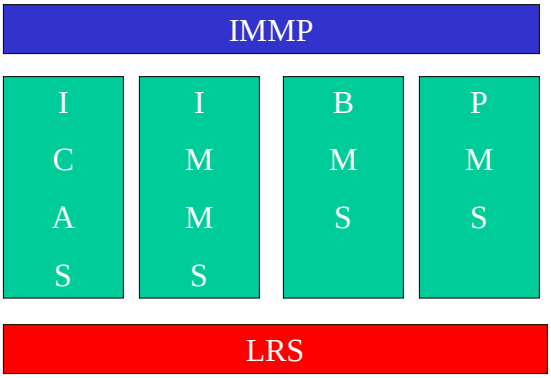
VDOT Organization



- 9 Districts plus a Central Office
  - Within each District is:
    - Residencies
    - Area Headquarters

ICAS LRS

- Inventory Condition and Assessment System
  - **State-wide Asset Database**
- Base for IMMP
- Foundation road network for VDOT
- To incorporate legacy HTRIS



ICAS Project Team

- Parsons Brinckerhoff
  - Prime and Data Collection
- Micheal Baker
  - Data collection and Data integration
- KPMG
  - SI
- Exor
  - Software and consultancy services

Data Sources

- Road center lines from GPS, local GIS, Digital Orthos, E911
- Legacy HTRIS nodes and sections geocoded
- Route information from HTRIS
- Assets collected using GPS

LRS Model

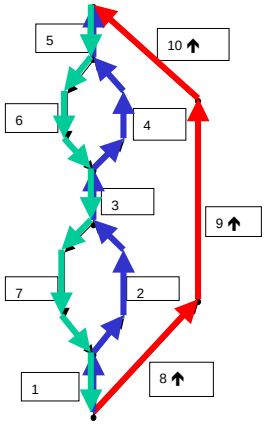
- User Group meetings
- Datum concept adopted
  - Intersection to intersection
  - No jurisdiction or temporally dynamic features
  - Ramps
  - Divided Highways
- 2-tier model
- LRMs include:
  - x,y
  - Route/milepoint
  - HTRIS legacy sections
  - Asset/offset
  - Address range
- History
- Multiple cartographic representations

LRMs and Transformations

- x,y
- Route/milepoint
  - Directional by number and Business options
- HTRIS legacy sections
  - Nodes and sections modeled
- Asset/offset
  - Any asset may be used
- Address range
  - Originally from TIGER, set against the datum

Route LRMs

c	Required Sections	Group Type	Sequence
17	1,2,3,4,5,6,7,8,9,10	Non-linear	In any order
17N	1,2,3,4,5	Linear	Exact order
17S	5,6,3,7,1	Linear	Exact order
17B	8,9,10	Linear	Exact order



Software implementation

- Exor network manager
- Data-driven
- Oracle client server
- ESRI spatial tools
- Document manager and asset manager for Assets

Exor Corporation

- International software provider
  - COTS
  - 12 years
  - Dedicated to highway management
- Offices in USA, UK, Italy, Australia, New Zealand
- 200 clients
- domain specialists:
  - Linear referencing & highway engineering
  - software design and development
  - Relational databases (Oracle)
  - Spatial expertise - not just GIS

Challenges and Lessons Learned:
Building VDOT's Enterprise GIS Using State of the Art Technology

Presented by:
Melanie R. Seigler, VDOT
Naveed Sami, VDOT
Bobby Harris, GIS/Trans, Ltd.

Presentation Overview

- Overview of Project Goals
- Enterprise Data Considerations
- Enterprise Architecture

Background

- Vision established in 1997-1998 for an enterprise approach to support future spatially enabled apps
- No vendor's COTS product was able to meet all requirements without major customization
- Project scope changed - no longer custom, but Commercial Off The Shelf (COTS)
- After evaluation ESRI's ArcSDE / ArcIMS / Oracle solution selected
- VDOT staffed their GIS Program to oversee development, testing and production

System Objectives

- Link business data to spatial data (LRS key)
- Serve traditional information to VDOT users in graphic format
- Provide a single point of access for enterprise spatial data for fat and thin clients
- Standardize spatial parameters to simplify the integration of various spatial data sets

System Objectives (Continued)

- Map server for query and display of maps through VDOT's intranet browsers
- Callable interface (API) accessible by popular programming languages and GIS scripts
- Integration of VDOT's multiple Linear Referencing Systems on common reference frame
- Integrated help to promote user friendliness

Objectives to be Phased-In as Industry Matures

- On-the-fly location referencing system conversions for disparate data including local data
- Information locator with strong metadata content
- Custom thin client interfaces
- Linkage to real time information such as ITS data

Who will the GIS Integrator Serve?

- Internal VDOT users
  - Used as a GIS data repository
  - Used as a model to build similar web-based projects in other VDOT business units
- Eventually Internet
  - Customer information system
  - Interagency data sharing

Enterprise Data Considerations

Melanie Seigler
GIS Applications Manager

Critical Data Issues

- Availability – what do we have to work with
- Quality – legacy systems, no standards, locational information
- Preprocessing – formats, projections
- Volume – 60,000 miles of road over a large area, 1.2 TB of aerial photography

Data Layers

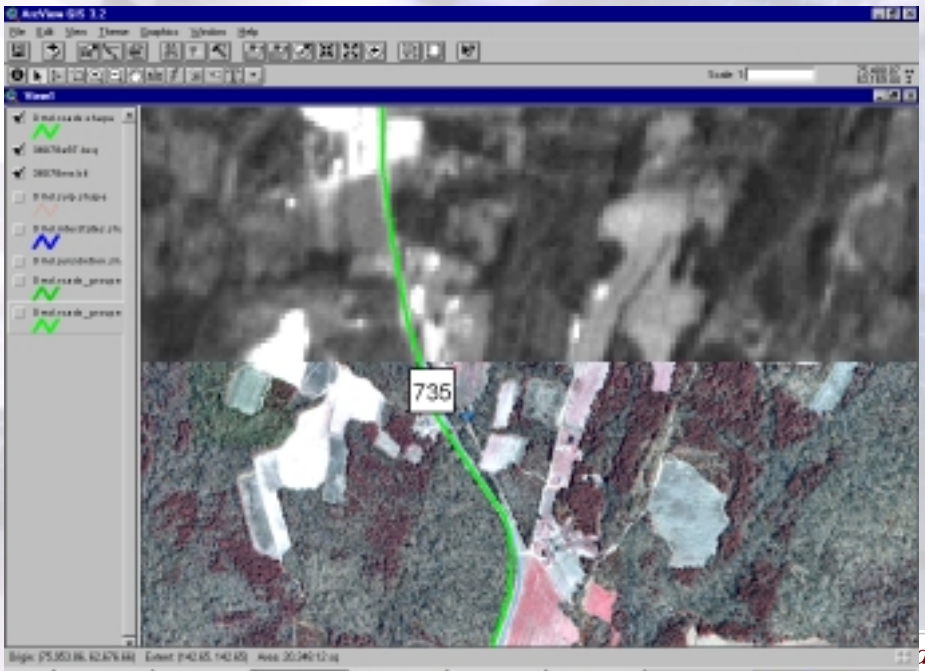
- Roads (All, Grouped, Measured shapes, ICAS Centerlines, Six-Year Improvement Program)
- Imagery - DOQQ & Right-of-Way
- Jurisdictional boundaries and water bodies
- Business Data: (Traffic, Accidents, Data Warehouse linkage to certain layers)

Imagery

- ROW Imagery
  - Obtained through Maintenance centerline data collection effort
  - forward images every 10th of a mile (52 ft)
- USGS Digital Ortho Quarter Quad
  - 1994-2000, color IR and/or black and white, 1m, 1:12000
  - 1.2 TB of images

VMRT
The Keep Virginia Moving

GIS Trans, Ltd.
A bd Systems, Inc. Company
GIS and Transportation Information Systems



Business Data

- Hosted as Materialized Views
- Spatially indexed
- Some data cleansing - LRS

Near Term Data Plans

- Data:
  - County Map Centerlines to ICAS Centerlines
  - Replace current LRS with ICAS LRS
  - Updated Imagery when available
  - More linkages to business data
  - Environmental Data (NWI, soils, T&E)

Enterprise Architecture Considerations

Naveed Sami
Director of Technology
Maintenance Division

Critical Design Issues

- Business Needs
  - 200 Concurrent Users over a Wide Area Network
  - 2 TB of Imagery
- Resulting System Needs
  - Large number of hard drives on data servers
  - Massive Data Backup
  - High bandwidth required between all servers
  - Significant Performance Tuning

Solutions

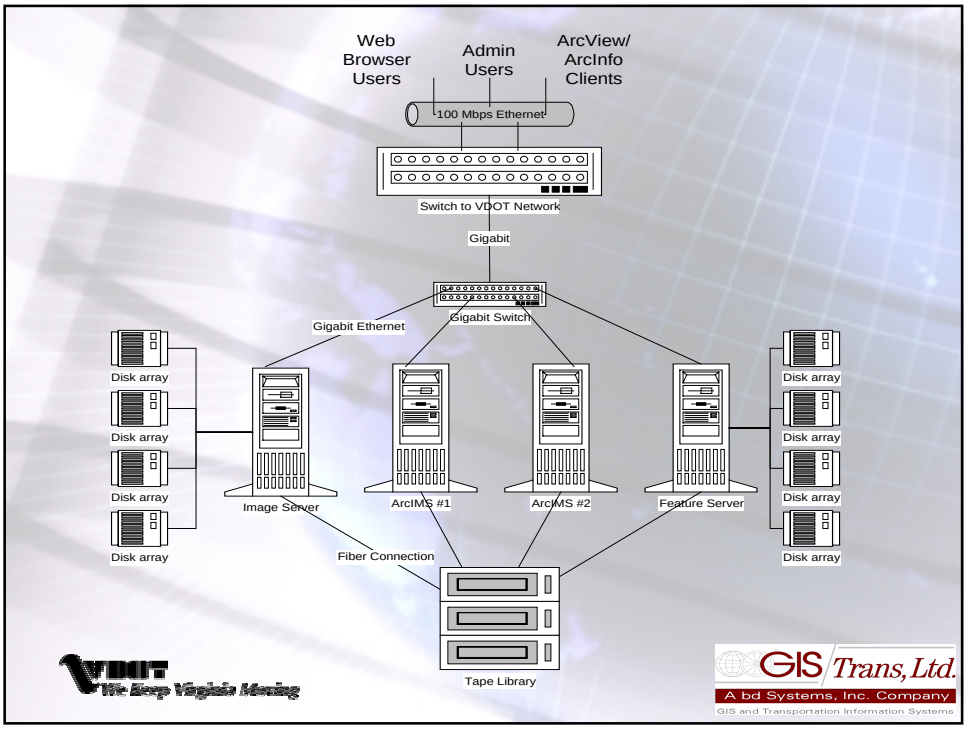
- Separate Business/Vector from Image data
- Configure for large Parallel I/O
- Group Vectors based on query needs
- Physically store feature tables in Spatial Index order
- Scale dependant rendering
- Thorough testing with custom designed Stress Testing Utilities

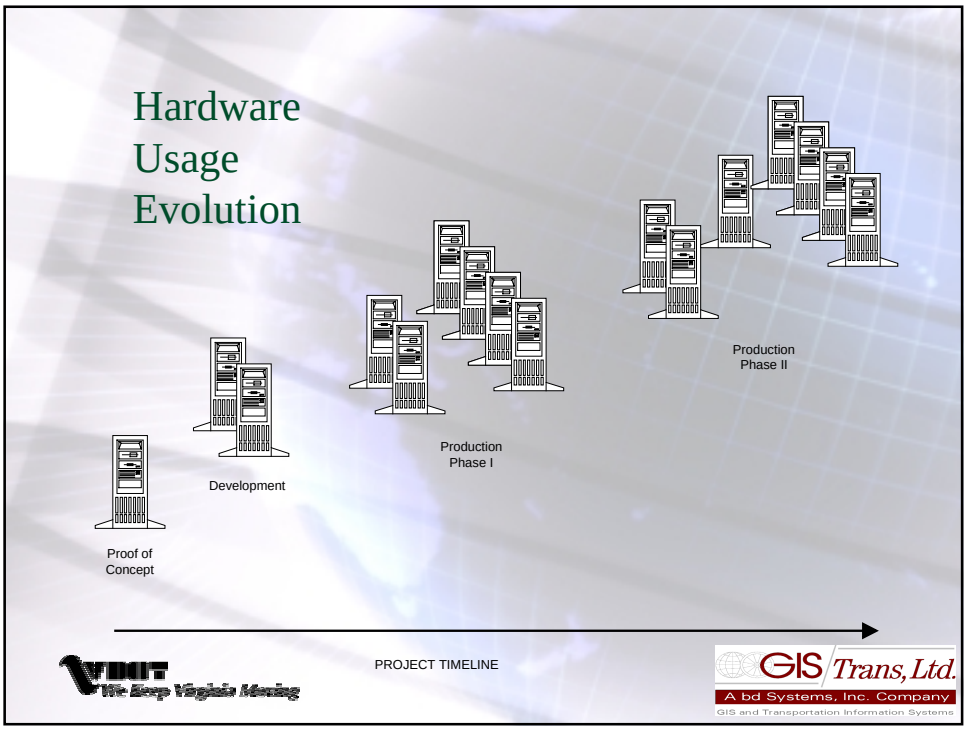
Two Data Servers

- Vector/Business
- Image
- Hardware
  - Quad CPU
  - 4GB RAM
  - 60 18GB hard drives
- Software
  - SDE
  - Oracle
  - Windows NT

Two Application Servers

- Hardware
  - Quad CPU
  - 4 GB RAM
  - 2 18 GB hard drives
- Software
  - ArcIMS
  - IIS
  - Windows NT


Web Browser Users
Admin Users
ArcView/ ArcInfo Clients
100 Mbps Ethernet
Switch to VDOT Network
Gigabit
Gigabit Switch
Gigabit Ethernet
Disk array
Disk array
Disk array
Disk array
Image Server
ArcIMS #1
ArcIMS #2
Feature Server
Disk array
Disk array
Disk array
Disk array
Fiber Connection
Tape Library
GIS Trans, Ltd.
A bd Systems, Inc. Company
GIS and Transportation Information Systems


Hardware Usage Evolution
Proof of Concept
Development
Production Phase I
Production Phase II
PROJECT TIMELINE
GIS Trans, Ltd.
A bd Systems, Inc. Company
GIS and Transportation Information Systems

Future Plans

- Incorporate new COTS functionality as available
- Performance Tuning (on-going)
- Just-In-Time Hardware Acquisition
- Support application needs of VDOT business units
- Provide common architecture that other business units can build their GIS on.

Contacts

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  - Melanie R. Seigler … 804-786-4966
- VDOT Maintenance Division
  - Naveed Sami … 804-786-0765
- GIS/Trans, Ltd
  - Bobby Harris … 301-495-0217, ext 126

Minnesota Department of Transportation

Building a Stable Method for Linear Location

A Mn/DOT Perspective

Dan Ross - Mn/DOT

Minnesota Department of Transportation

Outline...

- **Background**
  - **What prompted the move...**
- **Objectives and benefits**
- **Mn/DOT Model vs.. NCHRP 20-27**
- **The Project...**
- **Technology**
- **Implementation**
- **Conclusion**
- **Questions**
- **Business Issues - if there is time**

Minnesota Department of Transportation

Background...

- **Mn/DOT provides data to users on all transportation features**
  - **Roadway - all 138,000miles and 450,000+ segments**
  - **Different offices contacting LGAs for same info**
- **Several existing methods for transportation information**
  - **TIS, GIS BaseMap, AASHTO wares, other apps to use data**
  - **Distributed throughout**
- **History has been to capture info by linear location methods**
- **Linear Location continues to be important to us**

Minnesota Department of Transportation

Why is Linear Location Still Important to Us?

- More familiar - we have lots of current and past data using linear locations.
- More convenient
  - Little green signs are there and can measure from
- It is still sufficient for many of our applications
- Many times the accuracy of the data location relative to the transportation system (linear location) is more important than a relative one to the earth (coordinates).

Minnesota Department of Transportation

Leading up to the model...

- Many data sets with location component throughout the Department
  - Legacy systems
  - Many BA gathering same info
- Different referencing and coordinate systems
- Multiple software for editing and display
  - Many data formats
- No way to track history
- One voice to local partners
  - Many hops to get an answer or data
- Trusted source of transportation information
  - Mixing scales - planning for facilities mgmt.

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The Model...

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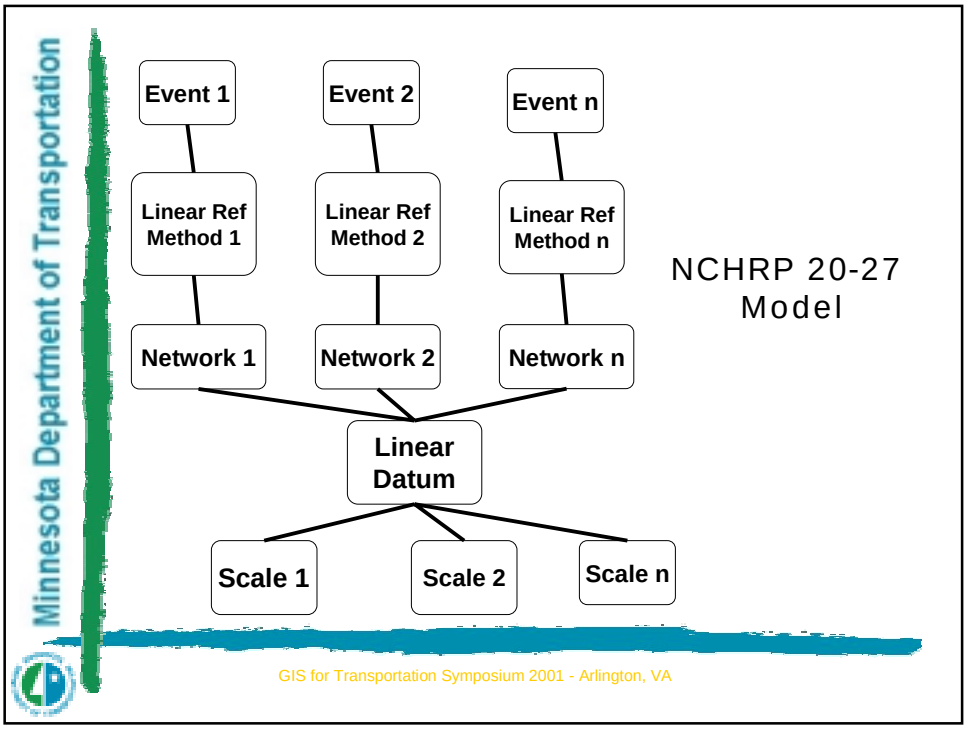
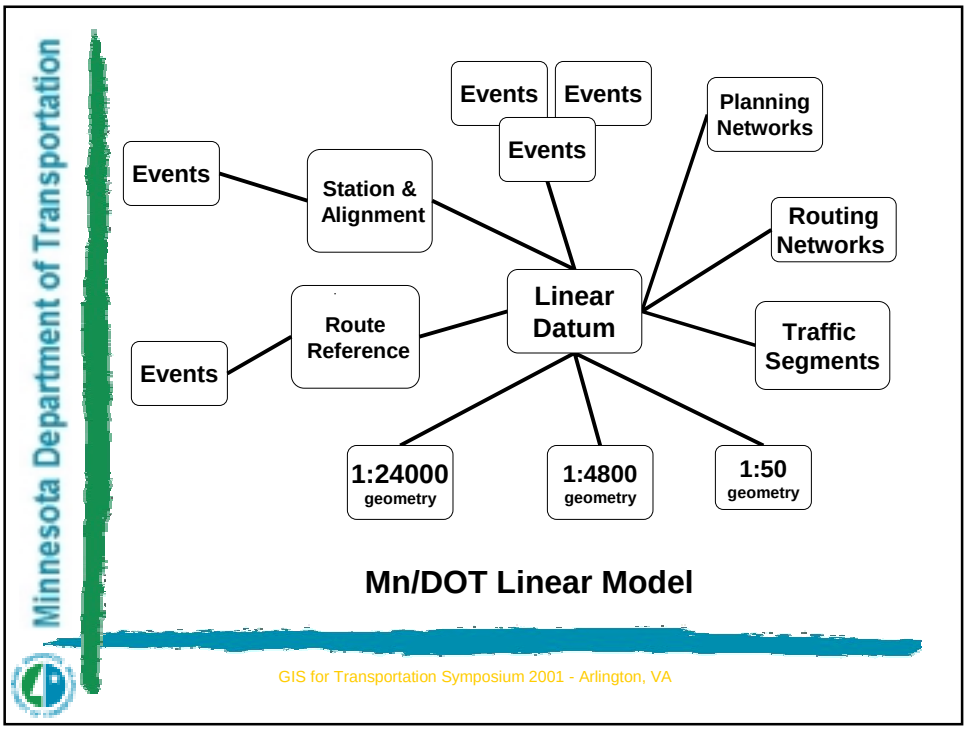

Minnesota Department of Transportation
Event 1
Event 2
Event n
Linear Ref Method 1
Linear Ref Method 2
Linear Ref Method n
Network 1
Network 2
Network n
Linear Datum
Scale 1
Scale 2
Scale n
NCHRP 20-27 Model
GIS for Transportation Symposium 2001 - Arlington, VA


Minnesota Department of Transportation
Events
Events
Events
Events
Station & Alignment
Planning Networks
Routing Networks
Linear Datum
Route Reference
Traffic Segments
Events
1:24000 geometry
1:4800 geometry
1:50 geometry
Mn/DOT Linear Model
GIS for Transportation Symposium 2001 - Arlington, VA

Minnesota Department of Transportation

Differences in the models...

- **Mn/DOT no NETWORK LAYER**
  - **Located data assigned directly to AS**
  - **Does not preclude us from having a network layer**
- **Anchor sections run intersection to intersection in Mn/DOT model**
  - **Larger number of records in database**
  - **Topologically correct**
  - **Match graphic reps**

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Mn/DOT's Anchor Point ...

- A place, which represents a road intersection, a road dead end/cul-de-sac, or the intersection of a road with a state boundary, where one or more anchor sections end.
- (Unique ID, X & Y coordinates to recover in the field) - Initially populated from the 1:24000 Mn/DOT GIS Base Map.

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Mn/DOT's Anchor Section...

- An anchor section is a concept that describes a continuous set of points that represent an intersection to intersection segment of the transportation infrastructure.
  - No AS where bridges occur, markers instead
- AS attributes - Unique ID, name, length, date, shape representation, anchor points associated)
- Other attributes associated with AS
  - Roadway characteristics (e.g. pavement type)

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Graphic Reps...

- **Model supports multiple graphic reps**
  - **Multiple scales**
  - **Each may have a different length**
- **Mn/DOT**
  - **Used statewide 1:24K BaseMap**
    - **Arc/Info to Oracle Spatial**
  - **Matched 1-1 with anchor sections**

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The Project...

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Mn/DOT's Location Data Management System...

- Status:
  - **$1.67 million foundational project in development stage**
  - **Iterative so several different processes at once**
    - **Just finishing up design of final elements**
    - **One delivery in-house, 3 to go**
      - **April, June, November**
    - **Current focus…**
      - **Testing**
      - **Rework - TISo, Hydraulics, Freight**

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General History...

- Started Investigating GIS Technology in the 1980's
- Established a GIS Taskforce early 1990's
- Released a Statewide GIS BaseMap in 1996
- Unified Transportation System (UTS) Project to replace the existing 30 year old mainframe system in 1997
- Developed a Conceptual Location Data Model in 1998 as part of the UTS project
- Implementation of the model 1999 - 2001 using two major information building blocks

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Existing Data...

- Transportation Information System (TIS)
  - A mainframe system almost 30 years old
  - Holds information on pavement, traffic counts, accidents, roadway history, bridge...
  - Uses route reference as a key field
  - Many small segments based on changes in attributes
  - Hard to maintain data when jurisdiction changes
  - Doesn't include ramps, loops, legs
  - No history capabilities
  - To be replaced with a new Unified Transportation System (UTS)
- Design Information (not in scope for this project)
  - No easy way to share

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Existing Mn/DOT BaseMap....

- Transportation Layer
  - Statewide 1:24000 scale
  - ESRI Arc/Info coverages
  - All Roads on separate coverages
  - Updated and released on CD-ROM annually
- Other 1:24,000 layers
  - Boundaries (City, County, USF&W, DNR…)
  - Rivers and Lakes
  - Railroads
  - Airports….

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Key objectives of the project...

- A system that will provide…
  - **A stable method for location and located data**
    - **Transparent to users** - (they can use current methods)
  - **A central storefront for location/located data**
  - **Tools for easy display and editing of map and tabular data**
  - **Import and conversion of various formats of data**
  - **Conversion between different linear reference methods**
  - **Conversion between coordinate systems**
  - **Conversion between spatial and linear reference**
  - **Shareable/Reusable tools and components**

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Two Mn/DOT Projects...

- IRM Project P075 - Location Data Server
  - **A foundational project that is needed by many of the other 150+ projects in Mn/DOT's overall IRM Plan.**
  - **Develop the systems that will capture, store and maintain the linear datum for all roads.**
- IRM Project P181 - BaseMap Enhancement
  - **A large data preparation project to add & enhance existing information on the Base Map for input into the location data server.**
  - **Combined road layers, named all segments, built routes on all public class levels**

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Benefits of building the data separately

- **Reduce the undertaking and risk**
- **Projects could be going on at the same time**
- **GIS Basemap has benefits outside of the model**
  - **Match with the TIS data**
  - **Reduce data redundancy**
  - **Provides data sharing opportunities with internal/external partners**
  - **Allows BA's to view and analyze their and other business data together spatially**
  - **Mn/DOT is a trusted resource for accurate transportation data**
  - **Our customers expect this to continue providing better data**

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ARCHITECTURE

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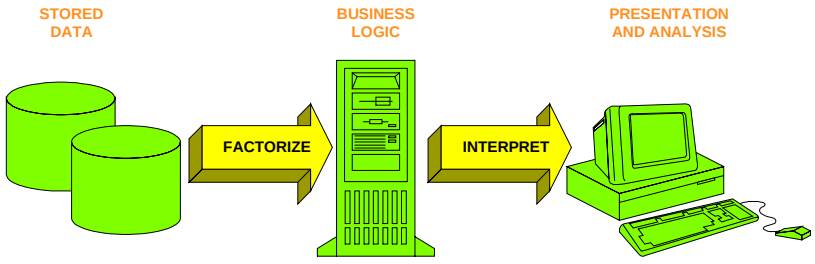
N-tier...

- A multi-tiered architecture provides the flexibility to achieve the goals mentioned.



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The Client

- **Client**
  - **Java GUI**
  - **15-20 users heavy client**
  - **Tools for display, editing**
- **Other clients to use services**
  - **Hydraulics, Freight**
- Future thin client

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The Middle Layer

- **Middle layer**
  - **Enterprise server**
  - **Components - services**
    - **Catalog**
    - **Dictionary**
    - **Coordinate/format conversion**
    - **Linear translations**
    - **Segmentation**
    - **Spatial analysis**

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Database level

- **Oracle 8i**
  - **Version 8.1.7**
  - **Spatial Cartridge**
- **Geometry moved over from Arc/Info**
- **Roadway characteristics from Oracle**

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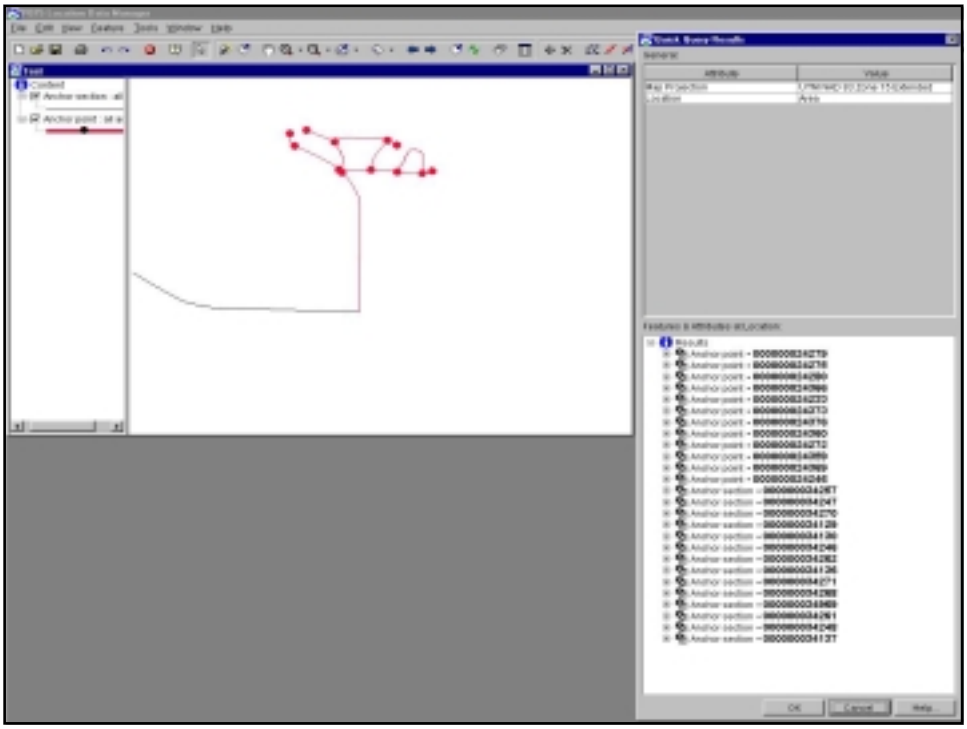
Tools...

- **Change groups**
- **Line/polygon editing tools**
  - **Create/edit graphic reps**
  - **Auto generate datum elements**
- **Attributes**
- **Routing and route posts**
- **Segmentation**
- **Coordinate conversion**
- **Format conversion**
- **Reference conversions**
- **Reports**
  - **Shapes, BaseMap**
  - **Logpoint**



Attributes...

Attributes for 00000031492 (Anchor section)

Attribute	Value
DefaultLength	2.488
ProposedActiveDate	
RetiredDate	
LastPostedTime	Nov 21, 2000
DefaultGraphicRep	000000031492
ActiveDate	Nov 21, 2000
LastEditedBy	BREE1KIR
Status	A
ToAnchorPoint	000000022311
Mode	RD
ProposalID	
TrafficDirection	N
FromAnchorPoint	apt000000022521
1998Accidents	0

Attributes for 2.488

Attribute	Value
Status	A
LastPostedTime	Nov 30, 2000
ActiveDate	Dec 6, 2000
ProposedActiveDate	
RetiredDate	
LastEditedBy	BREE1KIR
Source	BASEMAP
ProposalID	

Attributes for BASEMAP

Attribute	Value
SRS	UTM ZONE 015 NAD83
Type	DIGITIZED
Scale	1:24000
Accuracy	+-50 FT

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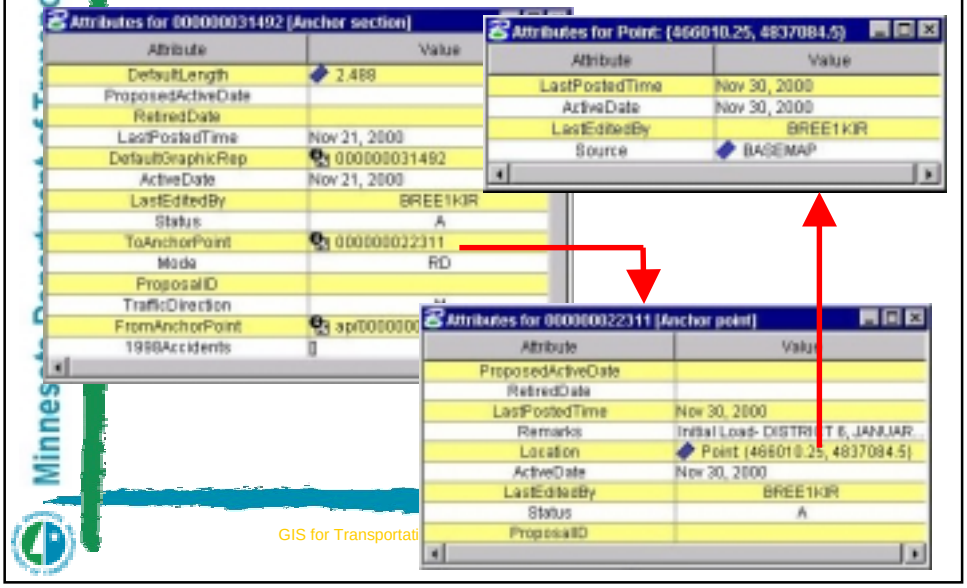
Nesting element attributes



Implementation

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The process...

- **Rational Unified Process**
  - Object oriented
  - Iterative
    - Design, build, test all going on together
      - Design phase3, Test phase 1, Build phase 2
    - Four deliverables
  - Move risk to the front of the project
  - First Mn/DOT project to follow this process
  - Very happy with results so far

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Staffing to build the model...

- **Two projects**
  - BaseMap
    - 12 Mn/DOT FTE 18 months
  - Linear Location Project - 18months
    - Requirements & Design
      - Mn/DOT - 3000 Employee Hours (EH)
      - Vendor - 4832 EH
    - Construction
      - Mn/DOT - 1000 EH
      - Vendor - 8360

Time required to implement

- **Test - planning, documentation, testing**
  - **Mn/DOT - 2460 EH**
  - **Vendor - 2096 EH**
- **Project Management**
  - **Mn/DOT - 1.5 FTE for 2 years (6240 EH)**
  - **Vendor - 1188 EH**
- **Miscellaneous - documentation, configuration management, transition, rework to other projects**
  - **Mn/DOT - 3100 EH**
  - **Vendor - 160 EH**

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Total staff investment

- **MN/DOT 53,240 hours**
- **Vendor 16, 872 hours**

70,112 Total employee hours

- **33.75 FTE for 1yr**
- **22.5 FTE for 18 months**
  - **Some Mn/DOT staff working on project for more that 18 months**
  - **Continue with other duties as well**

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Implementation issues...

- **Building new or off of the existing...**
  - **Mn/DOT chose to build off the current basemap**
- **In-house or external**
  - **Combination - Mn/DOT & Bentley Transportation**
- **How long should this take?**
  - **Predicted 18 months**
    - **Some delays**

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Implementation issues...

- Considerations
  - All road classes not just trunk (440,000+ segments)
  - Road names, route identifiers, and routes on all segments
  - Navigable waterways including routes
  - Railroads including routes
  - Markers
    - Bridges (20,000), RR crossings, weigh stations, RA's
  - Other related data (e.g. municipal boundaries)
  - Difficulty keeping local road info current

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Conclusion...

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Some Other Issues We've Faced...

- Linear Datum New Concept to Most
- Technical Architecture is Evolving
- Limited Project Team Experience
- New Object Oriented Design Process
- New Iterative Design Approach
- Government Contracting Process
- Crossing Office & Division Boundaries
- Team Dynamics - Keeping Enthusiasm & Momentum Over the Long Haul

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On the Up Side...

- Core Foundation Projects with Funding
- Continue to have Department Support
- Business Areas existed that managed linear types of data (creating new methods, not a whole new organization)
- Excellent Business Area Participation
- Good Problem Solving & Issue Resolution
- Business Areas are learning the magnitude of managing location information and the types of changes and new processes needed.

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Developing partners...

- **We now know business areas have a need for spatial linear data?**
  - **System will be hooked up to several BA's to start**
    - **Hydraulics, MDS, Freight, Markets & Products**
  - **Primary partnership between GIM and MDS**
- **External opportunities**
  - **One voice**
    - **Counties and Cities**
      - **GIS opened new doors**
      - **Interest by LGA's with no GIS**
      - **Many want to see the completed product**
    - **Private Sector**
      - **The Lawrence Group - sharing data back and forth**
  - **Future web interface to be built**

General comments...

- Issues are still ongoing
- We have developed and adopted issue solutions/ recommendations but…
  - Changes can be made during or after the completion
- Components change during the course of the project as technology evolves

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The Journey...

- We are still near the beginning of an ongoing journey.
- We will continue to incorporate lessons learned as things progress.
- We hope you have gained some insight on what Mn/DOT is doing
- We would like to see those that are following similar paths continue to share your lesson's learned as you go on your journeys...

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What's next?

- Crash
- Pavement
- Traffic
- Roadway History
  - Vertical perspective of roadway
- Bridge
- Asset management
- Design

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Questions?

Questions?

Questions?

Questions?

Questions?

Questions?

Contact Information...

- Dan Ross
  - Phone (651) 282-6113
  - Email daniel.ross@dot.state.mn.us

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Business and Data Issues

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Linear Base Data...

- **All road segments in the state**
  - 138,000+ miles and counting
  - All class levels
  - Includes ramps, loops, legs
  - Name(s) and route identifier for all
    - Match TIS
      - Flag those that did not match
      - Allows for plotting of information visually using GIS (e.g. accidents)
  - **Segments completed as intersection to intersection**
    - Anchor Sections

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Additional Base Data...

- Additional data needed for the project
  - **Railroads**
  - **Navigable waters**
  - **Markers -**
    - Bridges, RR, weigh stations, rest areas
    - Separate GIS coverage
  - **Jurisdictions - Ownership/Naming authority**
    - 23 Internal/External (e.g. Districts, US Forest Service)
    - Spatial Boundaries and contact info for most
    - Also included common query boundaries (e.g. USGS 24K tiles)

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Core Attributes...

- 440,000+ segments
  - **AS identifier - unique (12 numeric character)**
    - **Assigned by system**
    - **Can parse to meet NSDI Draft Standard**
  - **Road name**
    - **Which Road/Street name (Mn/DOT's, E911 etc.)?**
    - **Up to 4 one primary**
  - **Route identifier**
    - **Multiple BA's have ability to change or set**
  - **Class Identifier (e.g. 01 = Interstate, 02 = US Trunk Highway)**
  - **Roadway characteristics**
    - **Pavement type, # lanes, shoulder width, etc.**
    - **Assigned to anchor section**

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Anchor section issues...

- **Length - What length to use?**
  - **Several BA's maintain their own**
    - **Most Accurate - Construction Plans**
      - **OK for Trunk system - what about lower class roads?**
    - **Computer generated - GIS Basemap**
    - **State Aid**
    - **GPS**
  - **System will allow for multiple**
  - **Populated first time with computer generated**
  - **One length for each shape representation - documented regarding origin and accuracy**
  - **True mileage from TDA**
    - **Allows for plotting of events**

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Anchor Section issues...

- Intersection to intersection
- Do you break at a county or city boundary?
  - Mn/DOT - no
- Minimum length for AS
  - Much discussion - ended up 1/1000th of a mile (5.28 feet)
  - Looked at BA needs - (e.g. Bridge 2-5ft)
- How much can an AS/AP change before a new one must be put in?
  - A 5.28' change is not much
  - AS changes should only be associated with physical changes to the transportation network
    - Errors in data do not affect (e.g. more accurate shape or length)
  - 52.8 feet

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Anchor Section issues...

- How will divided highways be handled?
  - Several BA's maintain different definitions of what makes up a divided highway.
  - Poll and try to come up with a definition that will serve more than one BA
  - Anything separated by a barrier

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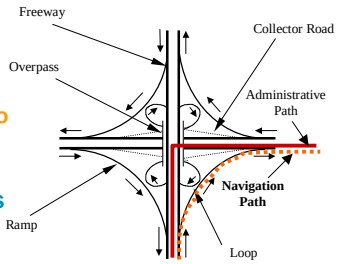
Building Routes...

- **Wide current user base**
  - **Multiple BA have a need**
    - **Both linear (e.g. pavement type) and point (e.g. accidents)**
    - **Not all BA's have the same routing needs**
      - **Administrative**
      - **Navigation path**
      - **Data nor currently in a form to support navigation path (e.g.junction segments)**
    - **BA's desire routes for all class systems**
  - **External customers**
    - **BaseMap CD - other government**



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Business issues...

- **When does a road become a road in the system?**
  - **System will support proposed roads**
  - **Shape and core info added when State Project or Charge ID assigned and preliminary drawings available**
  - **Route reference added when awarded for construction**
- **What can the status of an AS be?**
  - **Proposed - information about the segment exists but the segment is not open to traffic**
  - **Active - open to traffic**
  - **Retired - no longer in use**
  - **Removed - physically removed from the landscape**

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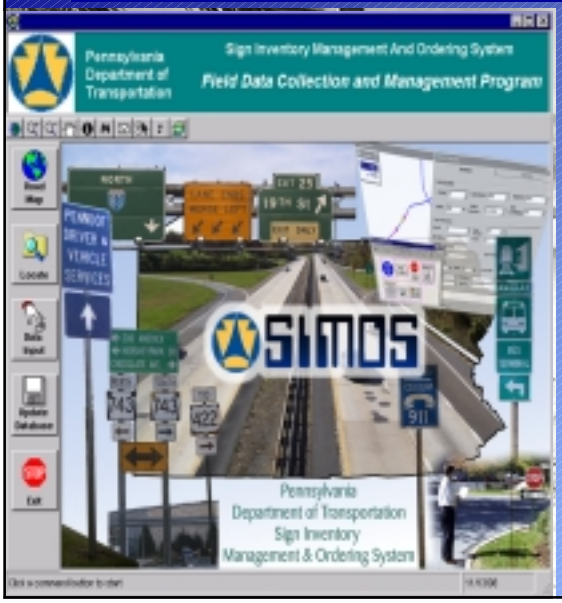
What Will PennDOT's *"Sign Inventory Management & Ordering System"* (SIMOS) Do?



Presented by:
Anthony J. Pietropola
Minhua Wang

April 9, 2001

GeoDecisions
A Division of Gannett Fleming, Inc.

Background

- Sign Tort Liability Is High - Est. $ 1.7 M /Year
- Eleven Unique Sign Management Systems
- No Statewide Inventory of Signs
- No Correlation Between Sign Shop Production and Field Needs
- Budgeting Based on Historical Expenditures - Not Needs
- Field Information Is Collected on Paper Maps and Reports

SIMOS

GeoDecisions
A Division of Gannett Fleming, Inc.

SIMOS Goals

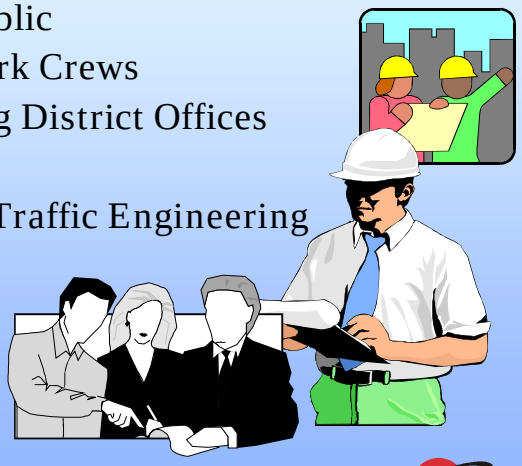
- Completely automate the process of collecting field data, processing work orders, ordering signs, and maintaining inventory
- Develop a comprehensive, centralized database
- Provide interface with other available databases at PennDOT
- Enhance PennDOT's ability to improve signage on a statewide basis, reducing tort liability

SIMOS

GeoDecisions
A Division of Gannett Fleming, Inc.

SIMOS Stakeholders

- General Public
- County Work Crews
- Engineering District Offices
- Sign Shop
- Bureau of Traffic Engineering



SIMOS

GeoDecisions
A Division of Gannett Fleming, Inc.

SIMOS Benefits

- Better Decision Making for Capital Budgeting
- Increase Operational Efficiency
- Lower Operation Costs
- Reduce Sign Order Errors
- Reduce Inventory of Signs
- Reduce Tort Liability
- Improve Sign Review Cycle Time

SIMOS

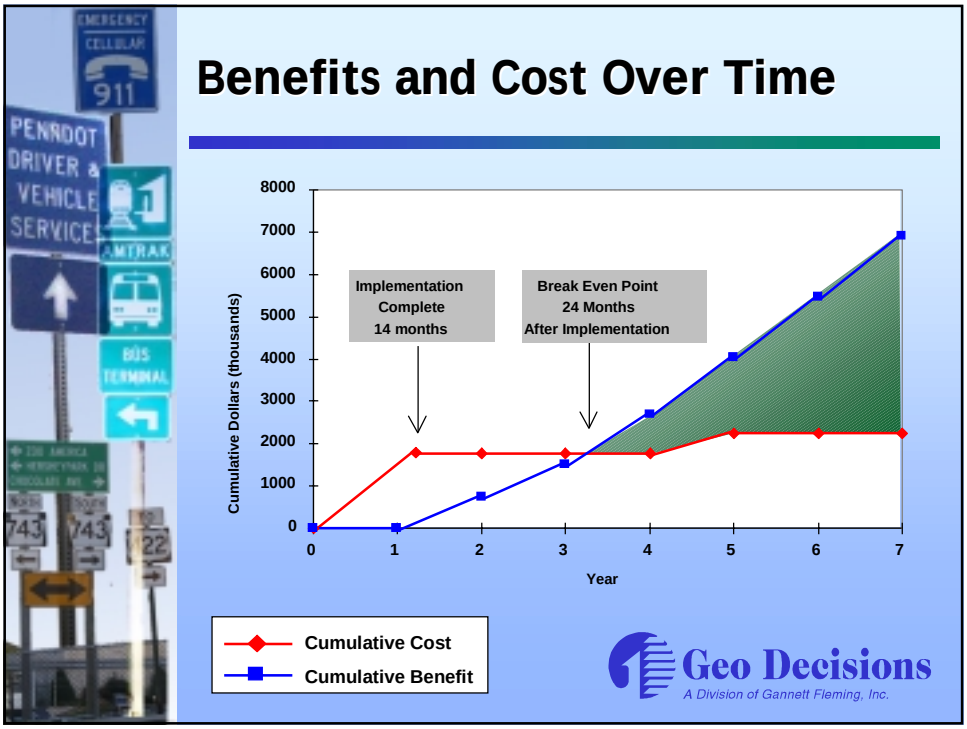
GeoDecisions

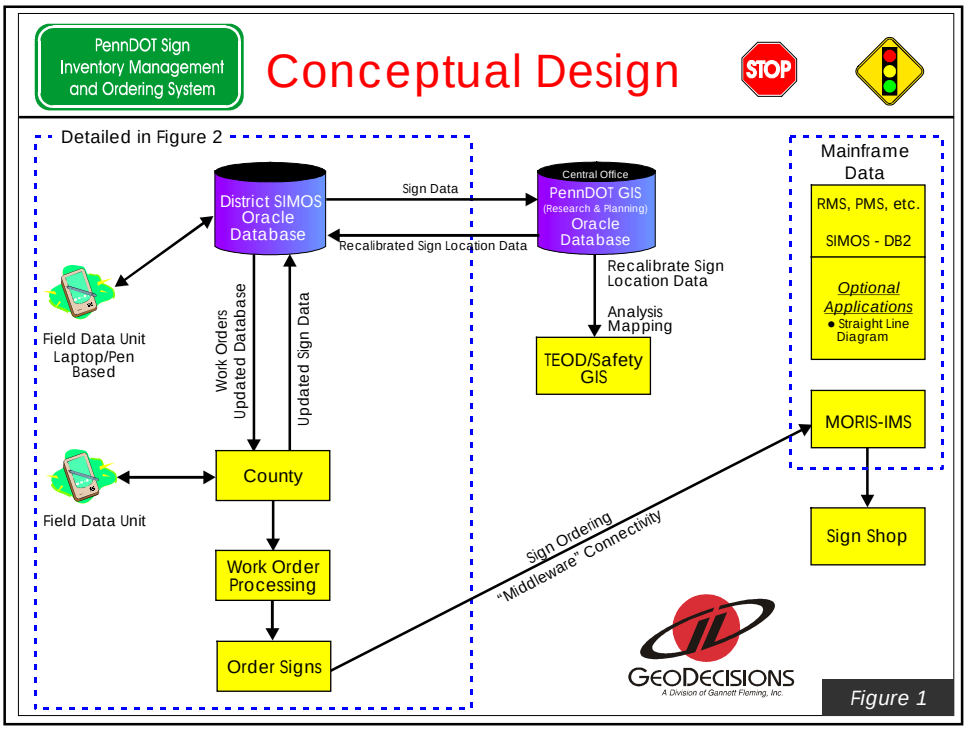
SIMOS Benefits

- General Public will Benefit
  - Better Signage/Safety
  - Most Effective Use of Tax Dollars

SIMOS

GeoDecisions


Benefits and Cost Over Time
Cumulative Dollars (thousands)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1
2
3
4
5
6
7
Year
Implementation Complete 14 months
Break Even Point 24 Months After Implementation
Cumulative Cost
Cumulative Benefit
Geo Decisions
A Division of Gannett Fleming, Inc.


PennDOT Sign Inventory Management and Ordering System
Conceptual Design
Detailed in Figure 2
District SIMOS Oracle Database
Sign Data
Central Office
PennDOT GIS (Research & Planning) Oracle Database
Recalibrated Sign Location Data
Recalibrate Sign Location Data
Analysis Mapping
TEOD/Safety GIS
Mainframe Data
RMS, PMS, etc.
SIMOS - DB2
Optional Applications
• Straight Line Diagram
MORIS-IMS
Sign Shop
Field Data Unit Laptop/Pen Based
Work Orders Updated Database
Updated Sign Data
County
Field Data Unit
Work Order Processing
Order Signs
Sign Ordering "Middleware" Connectivity
GEODECISIONS
A Division of Gannett Fleming, Inc.
Figure 1

SIMOS System Development

- Operating System: Windows NT/Win95/Win98
- Development Environment: Visual Basic
- GIS Engine: GeoMedia Objects
- Customized User-Friendly Graphic User Interface
- Why GeoMedia?
  - PennDot GIS Standard
  - Compatibility with Existing PennDOT Database

SIMOS

GeoDecisions

SIMOS System Components

- Field Data Collection Module
- Data Communication Modules
  - Field Data Unit to County Server
  - County Server to District Server
  - District Server to Central Office Server
- Work Order Generation Module
- Sign Order Generation Module
- Sign Location Recalibration Module
- Data Conversion Module

SIMOS

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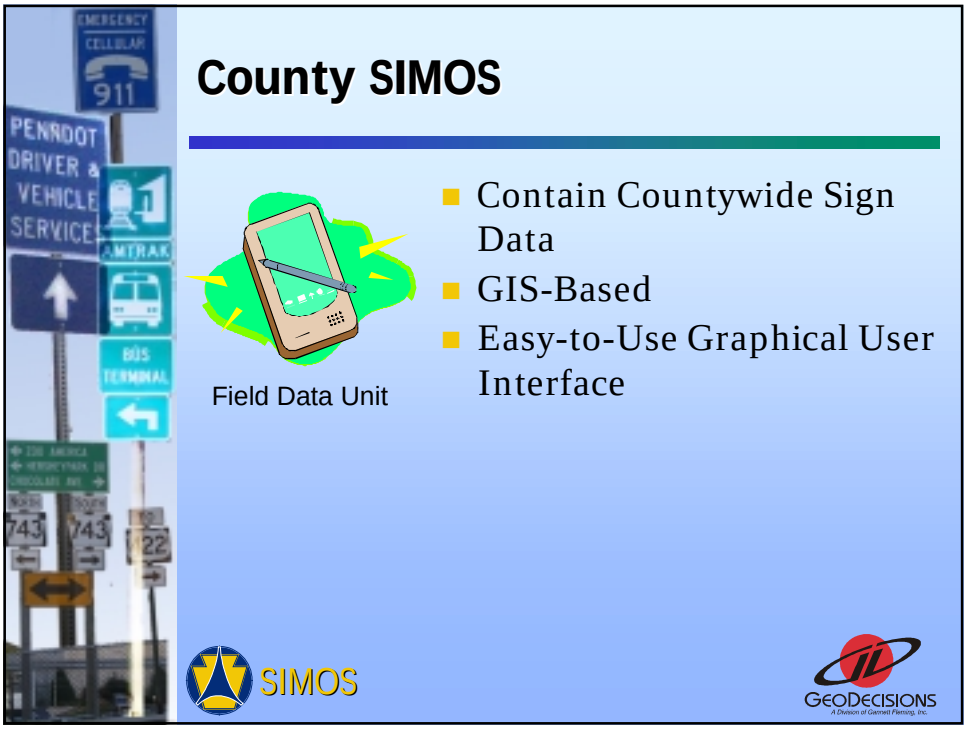


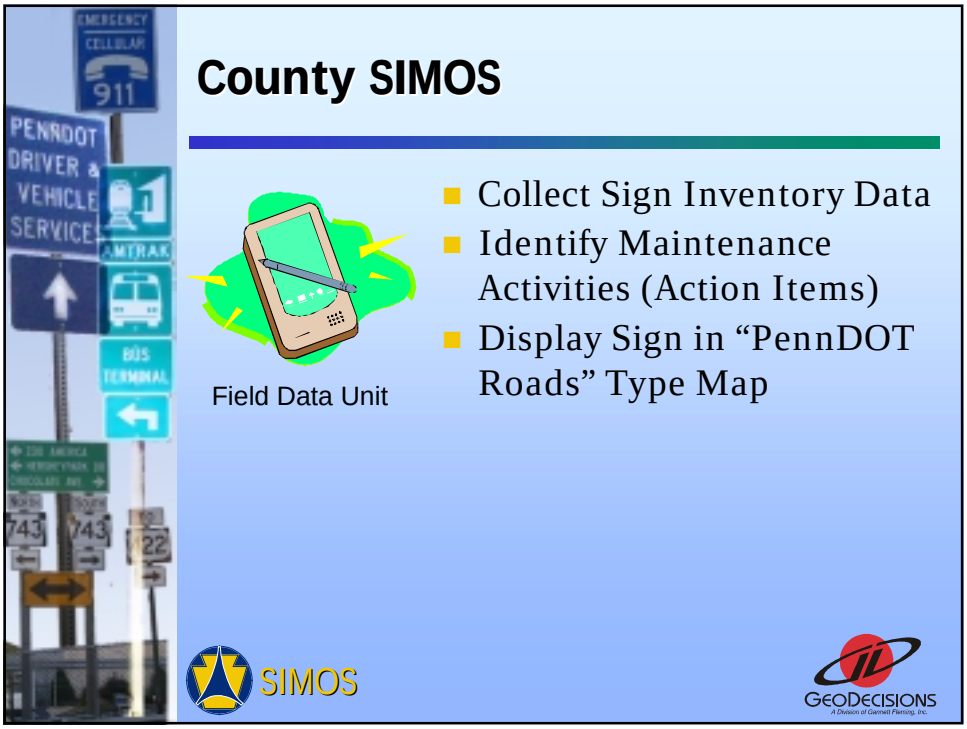
County SIMOS

Field Data Unit

- Contain Countywide Sign Data
- GIS-Based
- Easy-to-Use Graphical User Interface

SIMOS

GeoDecisions



County SIMOS

Field Data Unit

- Collect Sign Inventory Data
- Identify Maintenance Activities (Action Items)
- Display Sign in “PennDOT Roads” Type Map

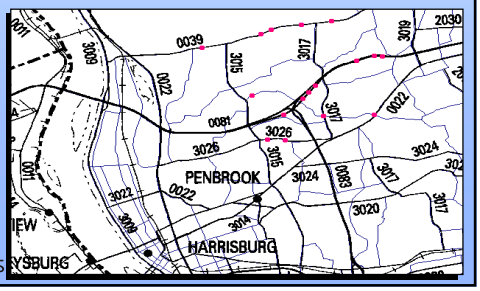
SIMOS

GeoDecisions

County SIMOS

Field Data Unit

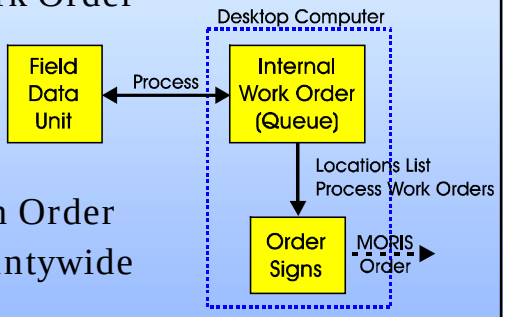
- Collect Sign Inventory Data
- Identify Maintenance Activities (Action Items)
- Display Sign in "PennDOT Roads" Type Map



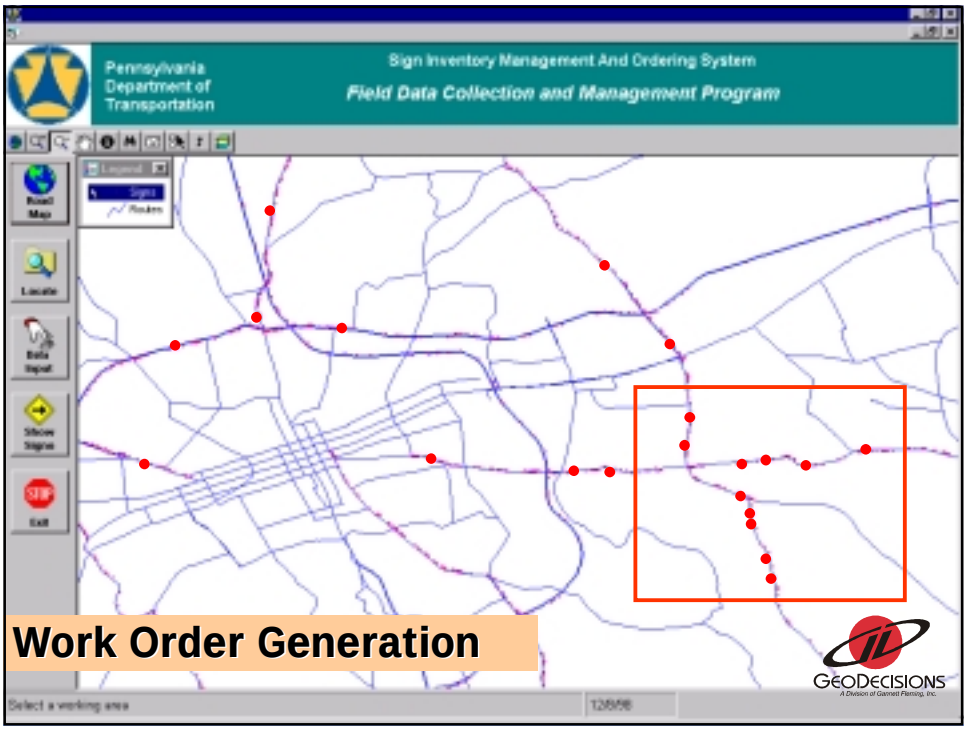
SIMOS GEODECISIONS

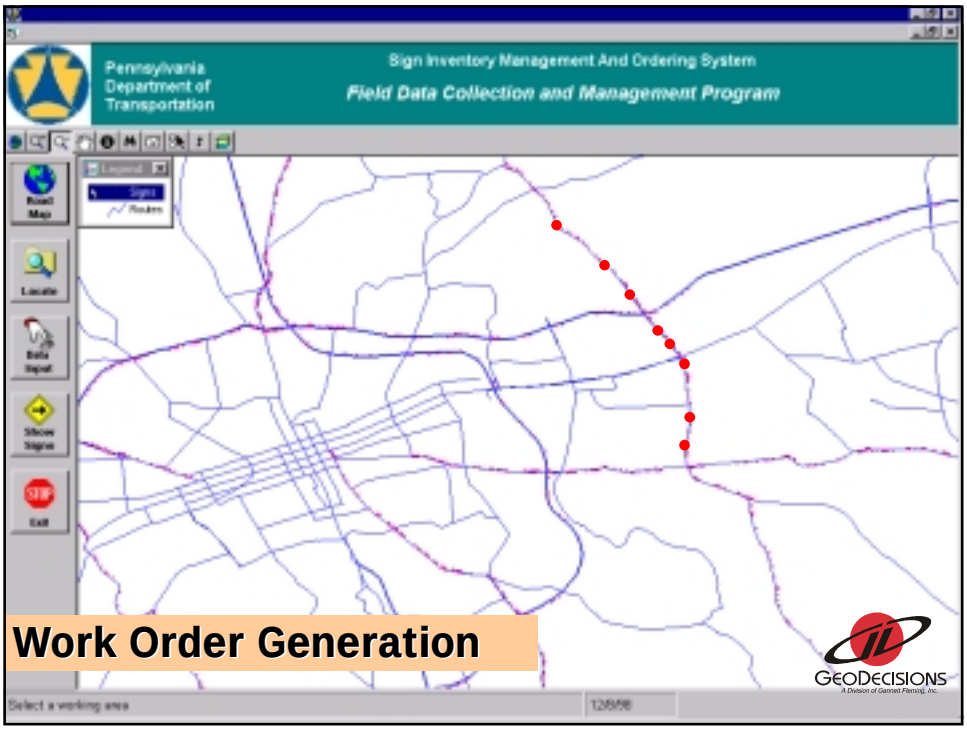
County SIMOS

- Maintain Pending Work (Queue)
- Generate Work Order
  - Date
  - Route
  - Location
  - Type
- Generate Sign Order
- Maintain Countywide Database



SIMOS GEODECISIONS


Pennsylvania
Department of
Transportation
Sign Inventory Management And Ordering System
Field Data Collection and Management Program
Work Order Generation
GEODECISIONS


Pennsylvania
Department of
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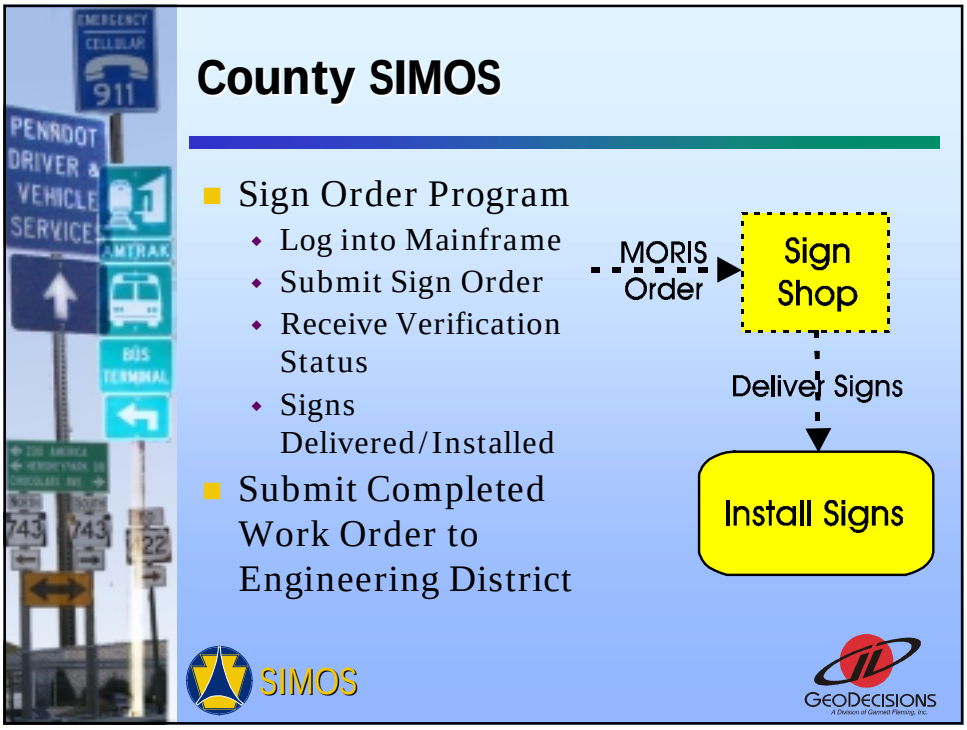
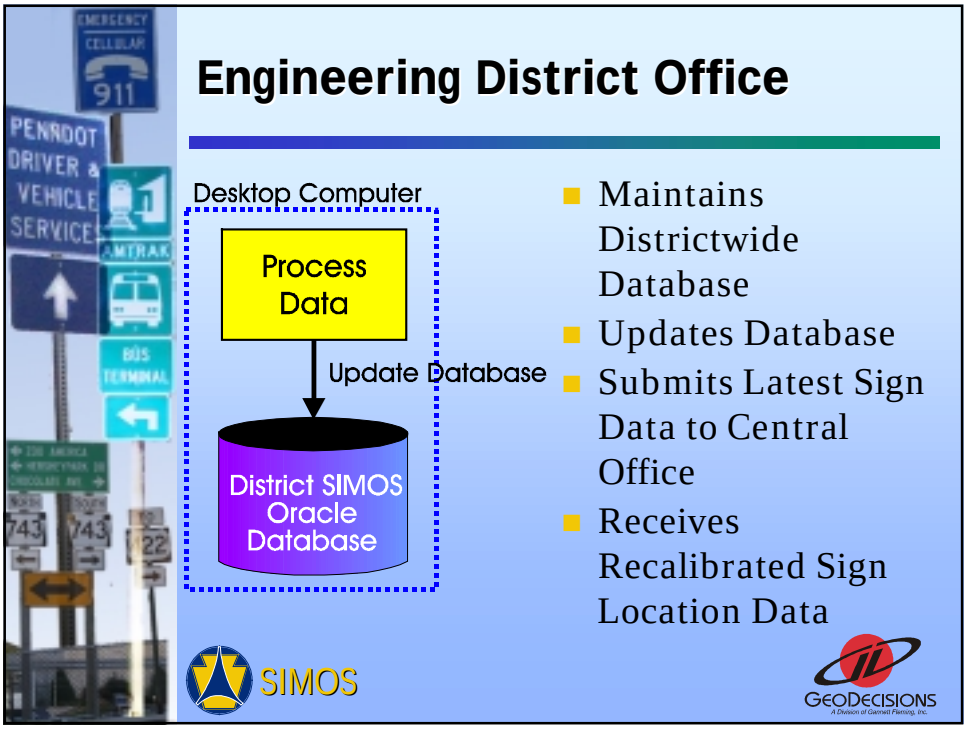
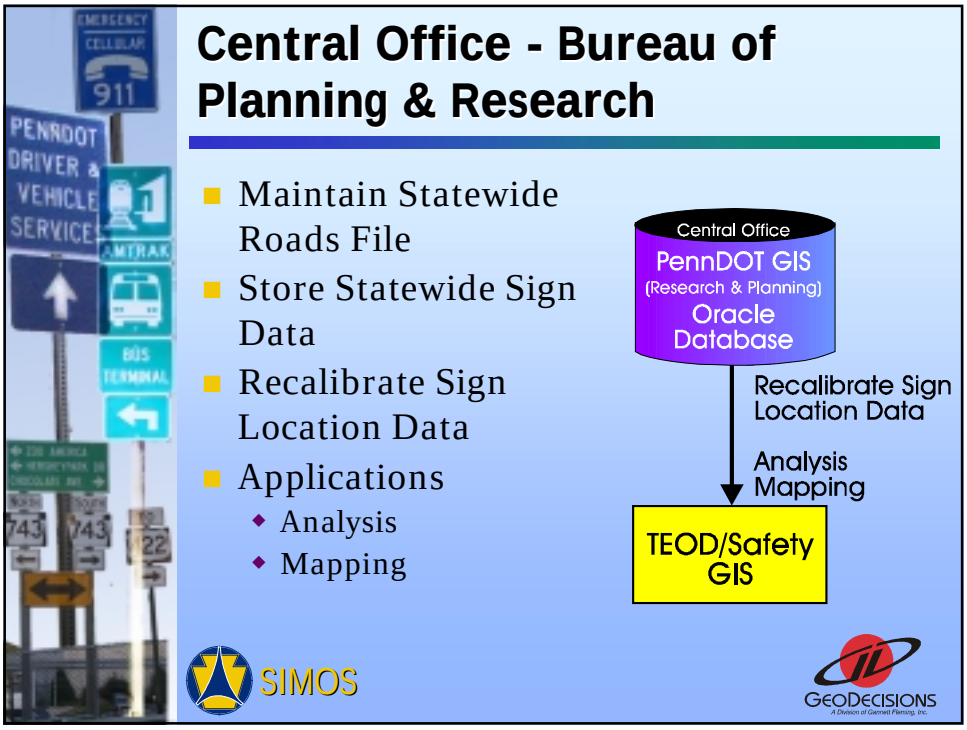
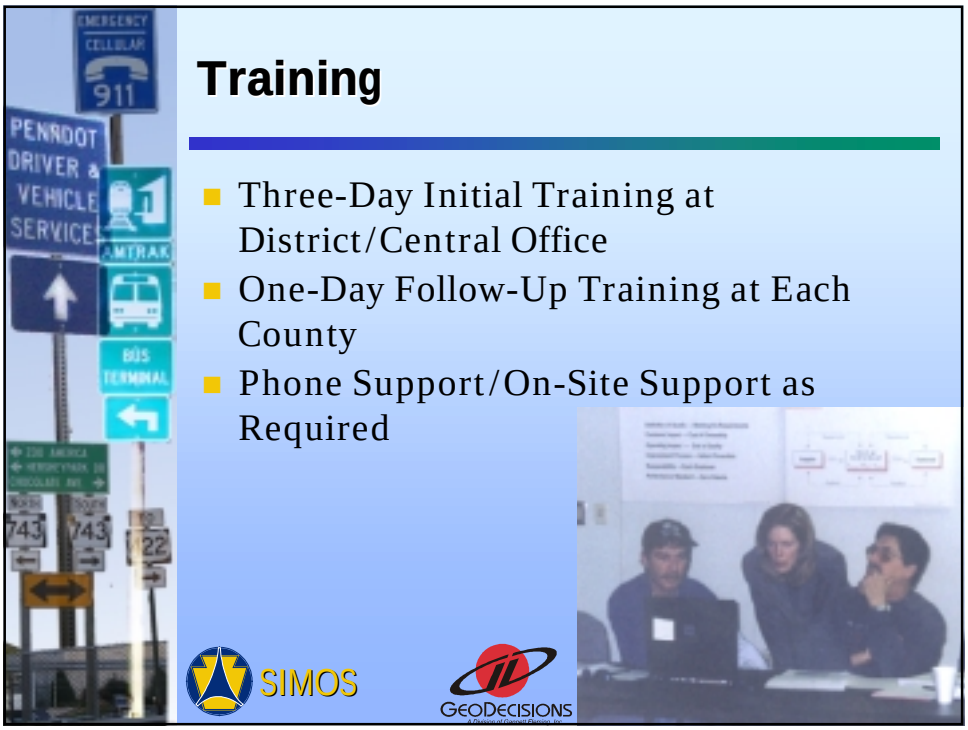
GEODECISIONS


County SIMOS
Sign Order Program
Log into Mainframe
Submit Sign Order
Receive Verification Status
Signs Delivered/Installed
Submit Completed Work Order to Engineering District
MORIS Order
Sign Shop
Deliver Signs
Install Signs
SIMOS
GeoDecisions


Engineering District Office
Desktop Computer
Process Data
Update Database
District SIMOS Oracle Database
Maintains Districtwide Database
Updates Database
Submits Latest Sign Data to Central Office
Receives Recalibrated Sign Location Data
SIMOS
GeoDecisions


Central Office - Bureau of Planning & Research
Maintain Statewide Roads File
Store Statewide Sign Data
Recalibrate Sign Location Data
Applications
Analysis
Mapping
Central Office
PennDOT GIS
(Research & Planning)
Oracle Database
Recalibrate Sign Location Data
Analysis Mapping
TEOD/Safety GIS
SIMOS
GeoDecisions


Training
Three-Day Initial Training at District/Central Office
One-Day Follow-Up Training at Each County
Phone Support/On-Site Support as Required
SIMOS
GeoDecisions

Project Status

- Project Completion - Winter 2000-01
  - Field Data Unit
  - Completed All Modules
  - PILOT Project (District 8 and Two Counties)
- Implemented & Trained 3 Districts and (16) Counties
- Remaining Districts (8) and Counties (51) by June 15, 2001

SIMOS

GEODECISIONS
A Division of Gannett Fleming, Inc.

SIMOS Demo

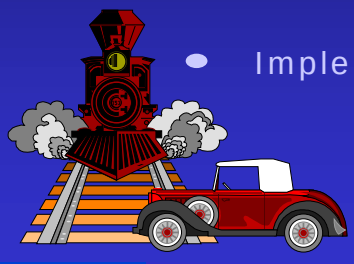
GEODECISIONS
A Division of Gannett Fleming, Inc.

April 9, 2001

GIS-T Symposium 2001
Arlington, VA

OPPORTUNITIES

- Safety Incentive Funds
- Advances in Data Collection Technology
- Implementation of New Software



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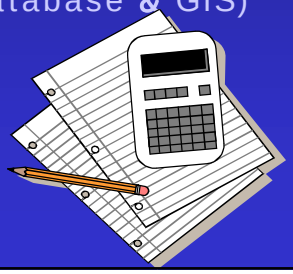
PHASE 1

- Establish Advisory Board
- Ranking Formula Review
- Evaluate Inventory Requirements
- Evaluate Collection Methods
- Evaluate Software (Database & GIS)
- Final Report



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PHASE 2

- Design Database Structure
- Collect Data
- Develop GIS Software
- Implementation
- Training

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FIELD STAFF

- Primary Crews - 26 workers,13 teams
- ADT Crews - 6 workers, 3 teams
- Crew Chiefs - 3 Supervisors

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TRAINING

- BNSF RR Safety Program
- UP RR Safety Program
- Operation Lifesaver
- Advanced Defensive Driving
- Red Cross First Aid

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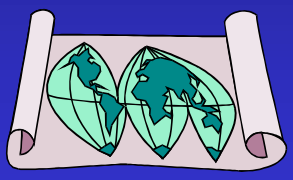
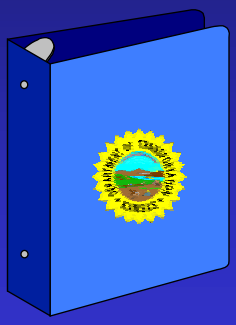
FIELD DOCUMENTS

- Field Manual
- Workflow Plan
- County/City Maps





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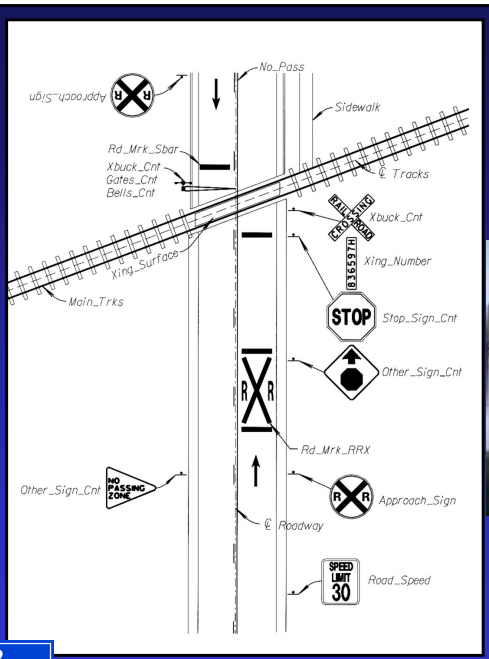
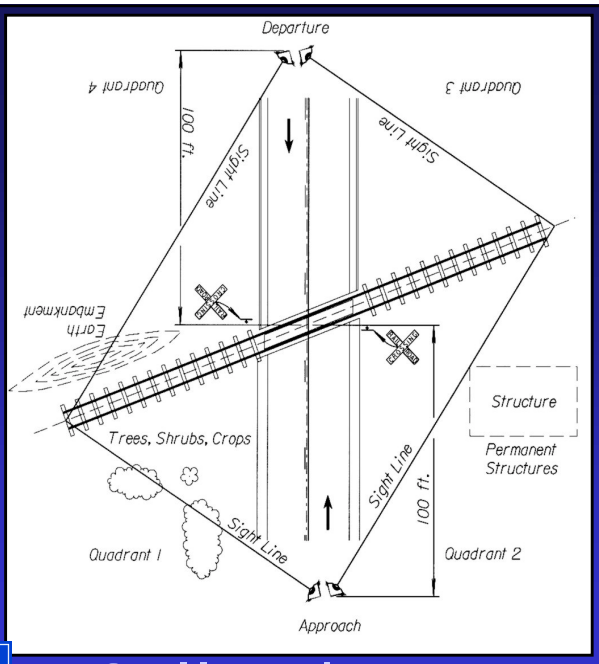


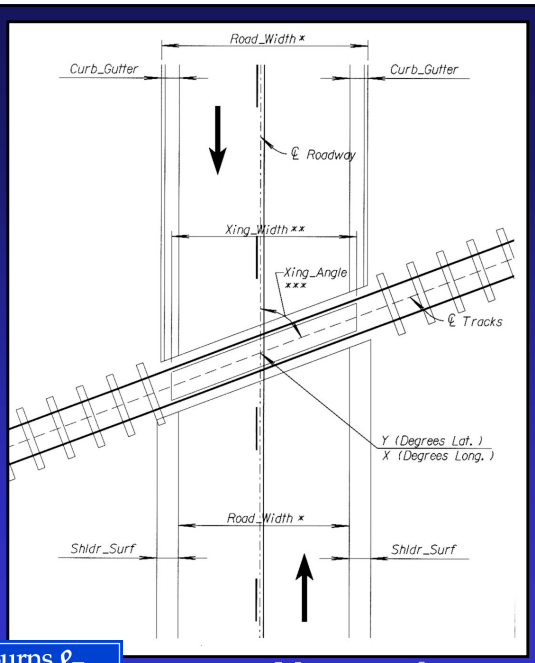
Burns & McDonnell SINCE 1898

Collection Items



Burns & McDonnell SINCE 1898

Collection Items



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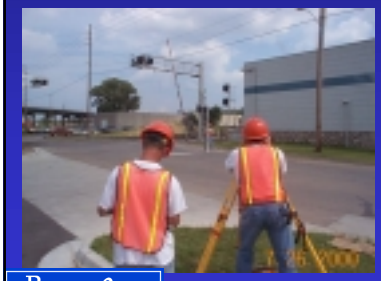
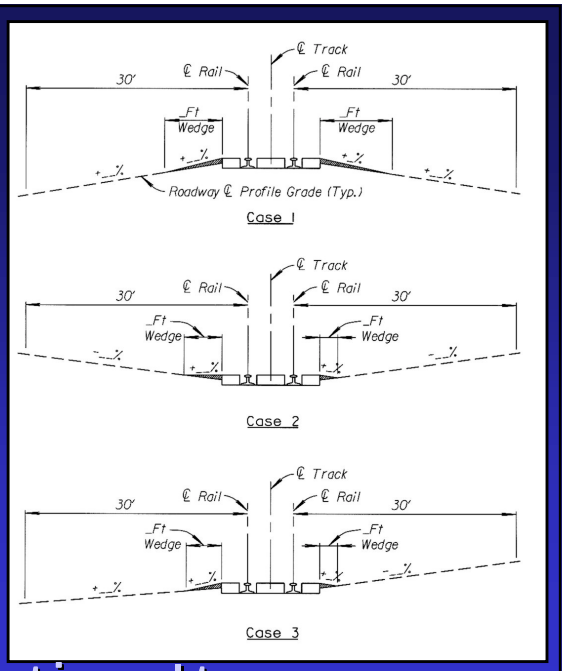
Collection Items





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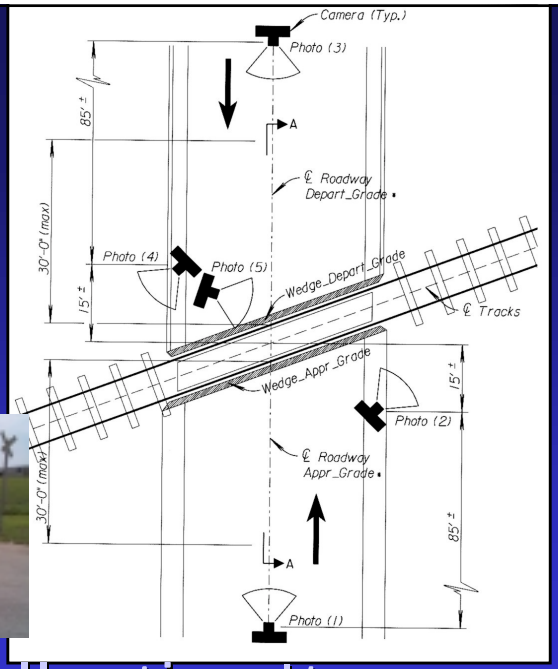
Collection Items



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Collection Items


2
5
6
3
4
Crossing Photos
Burns & McDonnell
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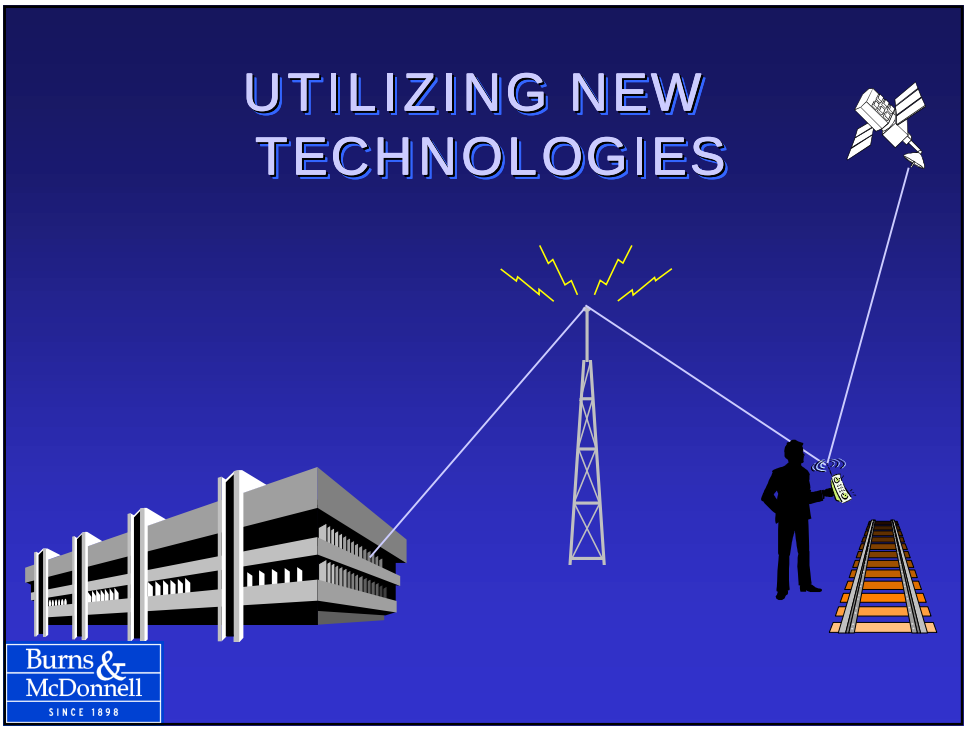
UTILIZING NEW TECHNOLOGIES
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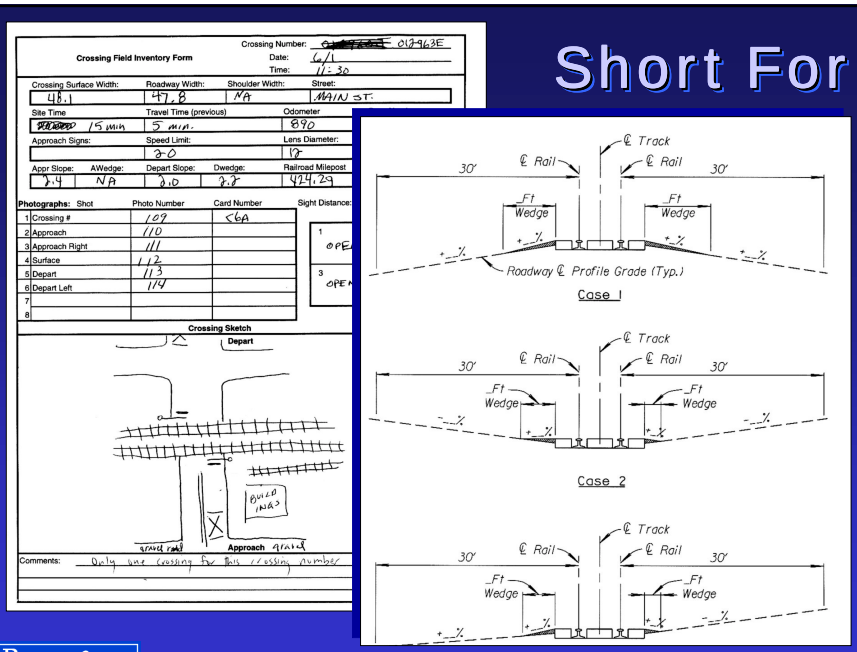
Short Form



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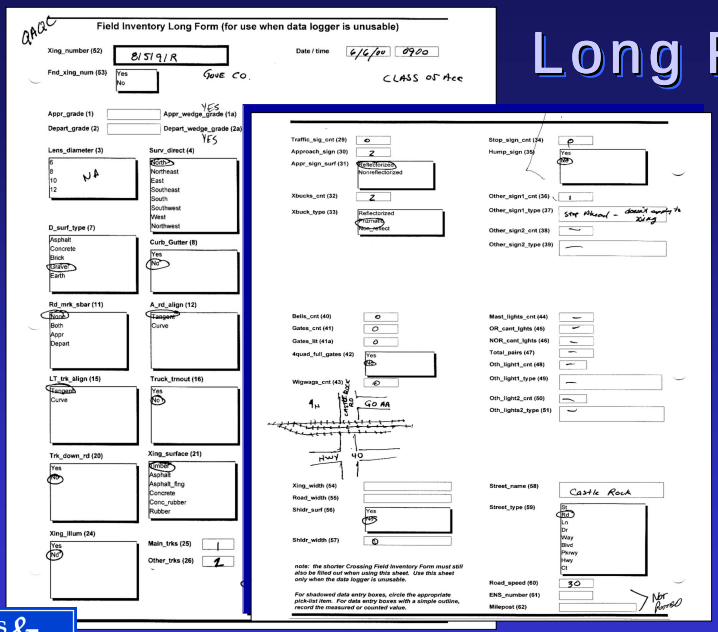
Long Form



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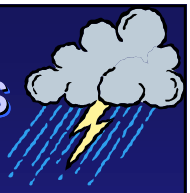
Project Challenges



- Weather
- Identifying Location
- Consistency Between Teams

- GPS Equipment
- Data Transfer
- Vehicle Problems

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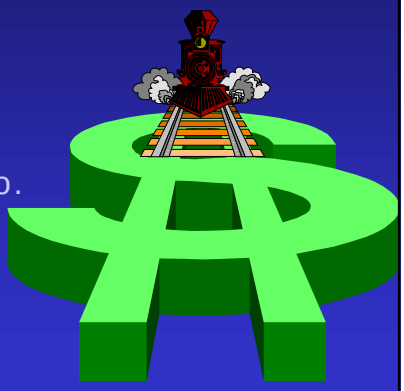
INVENTORY COST

- 6,500 crossings
- 103 counties
- Over 200,000 miles
- >400,000 pieces of info.
- $190 per crossing (Equipment & labor)



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CIIMS Overview

Crossing
Inventory
Information
Management
System

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CIIMS Overview

- Visual Basic API
- Intergraph GeoMedia Controls
- Oracle 8.1.6 database
  - Inventory data
  - Spatial data
- MS Access local database

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10

Data Sources

- Crossing Locations - GPS Inventory
- Railroad basemap - National Transportation Atlas (Bureau of Trans. Statistics)
- LRS Data - KDOT & Kansas Data Access Support Center
- Streets - TIGER (Census Bureau)

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CIIMS Demonstration

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11

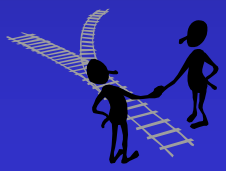
Final Thoughts

Include Impacted Organizations Statewide

Planning Is Essential

Assess Needs of End-users

Utilize Mainstream Technologies



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QUESTIONS

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12

A Web Based Traffic Count Information System

(http://www.dfwinfo.com/trans/tcins/index.html)

Mahmoud S. Ahmadi
Principal Transportation Engineer
and
Mark Sattler
GIS Analyst

Transportation Department
North Central Texas Council of Governments

Today's Presentation

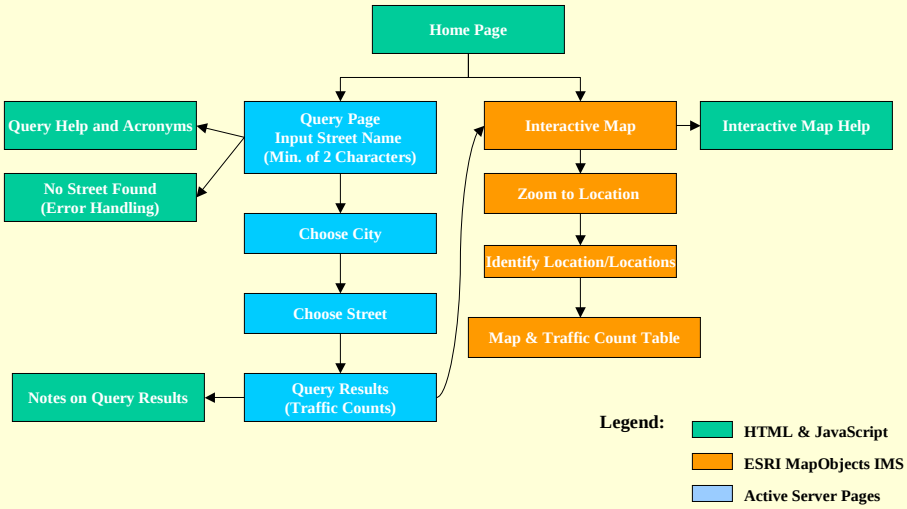
- Background
- System Architecture
- An Overview
- Development Environment
- Existing Information
- Cost Savings
- Future Enhancements
- Transportation DataMart

Background

- NCTCOG is the MPO for the Dallas / Fort Worth area
- One of the services, among many, is to provide traffic counts to both public officials & private citizens
- Streamline the process by providing the information on the web

North Central Texas Council of Governments

System Architecture

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Welcome to the North Central Texas Council of Governments
Transportation Department
Friday - April 6, 2001
Transportation Topics
MOBILITY 2025: THE METROPOLITAN TRANSPORTATION PLAN
TRANSPORTATION IMPROVEMENT PROGRAM (TIP)
2000-2001 UNIFIED PLANNING WORK PROGRAM (UPWP)
BIKE AND PEDESTRIAN
LAND USE TRANSPORTATION INTERFACE
AIR QUALITY
CLEAN CITIES (ALT. FUELS)
TRANSIT PLANNING AND TRAVEL DEMAND MANAGEMENT
FELLOWSHIP PROGRAM
In the Department
AGENCY CALENDAR
Today's Spotlight
2002 Transportation Improvement Program...
View the Draft 2002 TIP Project Listings.
More of this story...
Online Publications
View a variety of PDF documents here...
Traffic Count Information System
DFW traffic counts are now online! Click here to begin.
Other Spotlights...
UPDATED Transportation Fellowship Program Applications Due May 18th
NEW April Public Meetings
NEW Mobility 2025 Update Technical Workshop Packet
DFWTraveler.com
Links to real-time traffic information, roadway
Document: Done


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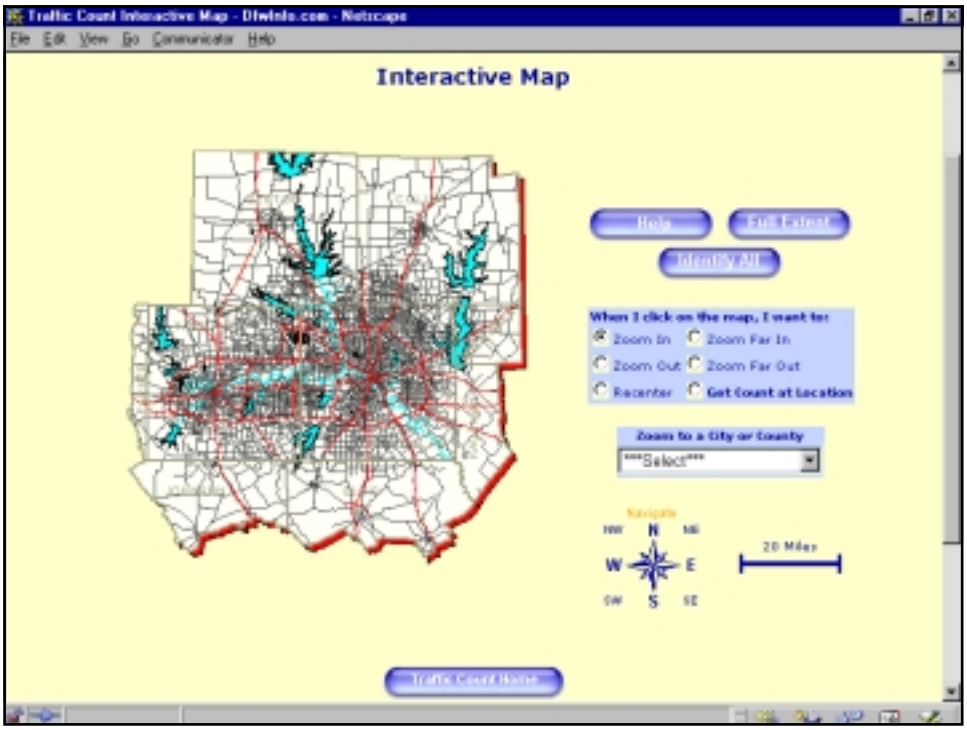
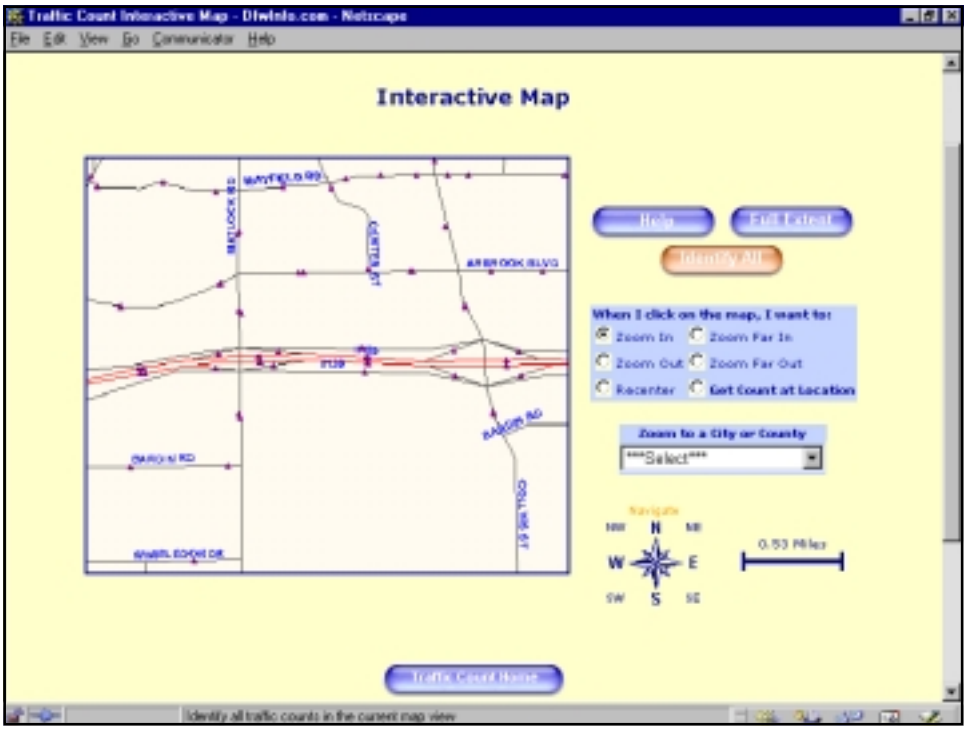
Transportation Department
Traffic Count Information System: Home Page
Welcome to NCTCOG's Transportation Department's Traffic Count Information System. This site is designed to provide a listing of the most recent traffic counts provided to NCTCOG by local municipalities within the metropolitan area and by the Texas Department of Transportation (TXDOT). Historical traffic counts (prior to 1995) can be obtained by contacting Mahmoud Ahmadi at (817) 695-9091. Traffic counts are estimated vehicle volumes for an average 24-hour period. The information on this site is periodically updated; the last update was January 2001.
Please select one of the following methods to begin your search:
Use interactive map to identify locations in your area of interest
Query using parameters that you input (street name and city)
Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration. The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the views or policies of the Federal Transit Administration, the Federal Highway Administration, the U.S. Department of Transportation, or the Texas Department of
Document: Done


Traffic Count Interactive Map - DfwInfo.com - Netscape
File Edit View Go Communicator Help
Interactive Map
Help
Full Extent
Identify All
When I click on the map, I want to:
Zoom In
Zoom Far In
Zoom Out
Zoom Far Out
Recenter
Get Count at Location
Zoom to a City or County
Select
Navigate
N
W
E
S
20 Miles
Traffic Count Home


Traffic Count Interactive Map - DfwInfo.com - Netscape
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Interactive Map
Help
Full Extent
Identify All
When I click on the map, I want to:
Zoom In
Zoom Far In
Zoom Out
Zoom Far Out
Recenter
Get Count at Location
Zoom to a City or County
Select
Navigate
N
W
E
S
0.53 Miles
Traffic Count Home
Identify all traffic counts in the current map view


Traffic Count Interactive Map - Dfwinfo.com - Netscape
File Edit View Go Communicator Help
Identify Results:
Location
City
Source
Year
Vehicles per Day
COLLINS ST between FRE IH20 and BARDIN RD
ARLINGTON
TXDOT SATURATION
1995
19,804
COLLINS ST between FRE IH20 and BARDIN RD
ARLINGTON
CITY OF ARLINGTON
1995
19,018
IH20 EB between RPCOLLINS IH20 and RPS COLLINS
ARLINGTON
TXDOT RAMPS
1996
69,200
IH20 OFFRAMP EB between E IH20 and S COLLINS ST
ARLINGTON
TXDOT RAMPS
1996
9,340
IH20 OFFRAMP WB between W IH20 and S COLLINS ST
ARLINGTON
TXDOT RAMPS
1996
6,500
IH20 ONRAMP EB between S COLLINS and E IH20
ARLINGTON
TXDOT RAMPS
1996
7,190
IH20 ONRAMP WB between W IH20 and S COLLINS
ARLINGTON
TXDOT RAMPS
1996
9,420
IH20 WB between RPS COLLINS and RPCOLLINS IH20
ARLINGTON
TXDOT RAMPS
1996
70,110
Traffic Counts are estimated vehicle volumes for an average 24-hour period.
Counts on freeways have been adjusted for vehicle type; click here for more information.
Click here to view a list of the Traffic Count Database's abbreviations and acronyms


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NCTCOG Jobs
Transportation Department's Traffic Count Information System
To begin your query, type in a road name or a search string at least 2 characters long.
DIV
enter
Example: For Belt Line Rd, you could enter the search string "belt"
Click here to view a list of the Traffic Count Database's abbreviations and acronyms
DFWINFO.COM
Legal Disclaimer
North Central Texas Council of Governments
616 Six Flags Drive P.O. Box 5888 Arlington, TX 76005-5888
Transportation Dept. Phone: (817) 695-9240 Fax: (817) 640-3028
Document: Done

Street	City	Source	Year	Vehicles per Day
SH180/DIVISION ST between 108TH ST and GREAT SOUTHWEST PKWY	ARLINGTON	CITY OF ARLINGTON	1995	28399
SH180/DIVISION ST between BOWEN RD and OAKWOOD ST	ARLINGTON	CITY OF ARLINGTON	1995	22478
SH180/DIVISION ST between BOWEN RD and OAKWOOD ST	ARLINGTON	TXDOT SATURATION	1995	24219
SH180/DIVISION ST between COOPER ST and CENTER ST	ARLINGTON	CITY OF ARLINGTON	1995	20878
SH180/DIVISION ST between COOPER ST and CENTER ST	ARLINGTON	CITY OF ARLINGTON	1995	23026
SH180/DIVISION ST between COOPER ST and CENTER ST	ARLINGTON	TXDOT SATURATION	1995	21900
SH180/DIVISION ST between CROWLEY RD and BOWEN RD	ARLINGTON	CITY OF ARLINGTON	1995	24499
SH180/DIVISION ST between DAVIS RD and JEFFERSON	ARLINGTON	CITY OF ARLINGTON	1995	21640
SH180/DIVISION ST between DAVIS RD and JEFFERSON	ARLINGTON	TXDOT SATURATION	1995	20329

Development Environment

- HTML for basic web page creation
- ASP (Active Server Pages) for database querying and display
- JavaScript for special page features
- Visual Basic 6.0 with MapObjects 2.0 and MapObjects IMS 2.0 for mapping
- Compatibility with our TIP System

  (http://dfwinfo.com/trans/tipins/index.html)

Existing Information

- 12,726 locations from 1995 TxDOT saturation counts
- 1,610 locations from different cities (1996, 1997 & 1998)

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Cost Savings

- **Prior to the system:**
  - Almost one full time person was assigned to providing the information
  - 1 ~ 2 hours turn around
- **After the system:**
  - Work load is reduced by 90%
  - Instantaneous results for the system users
  - 150 hits per day

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Future Enhancements

- **Short Term (June 2001)**
  - ➢Add 1999 TxDOT saturation counts
  - ➢Add more traffic counts from cities
- **Long Term**
  - ➢Develop an automated system for cities to upload their traffic count data into the system ***(Use of GPS)***

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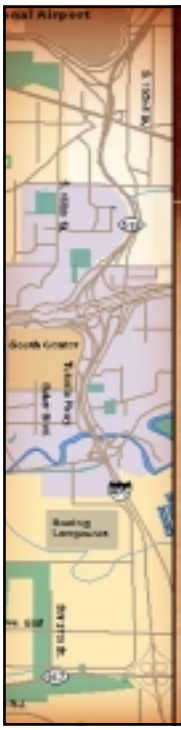


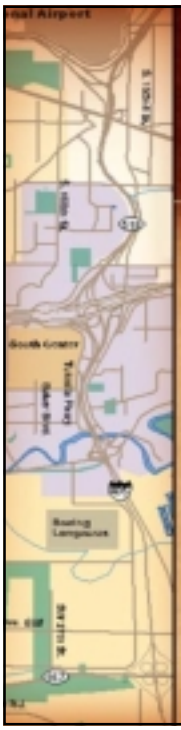
CH2MHILL

Developing a WebGIS for PSRC's Transportation Improvement Program

Presented to

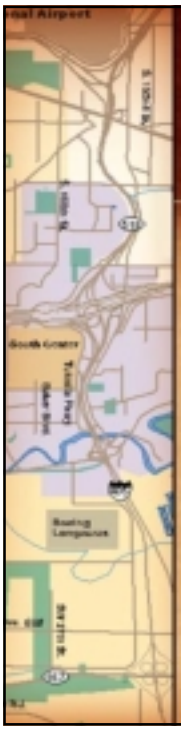
GIS-T 2001

Crystal City, VA



Presentation Outline

- Background
- Goals and Purpose
- Challenges
- Methodology
- Results



Puget Sound Regional Council

- **Seattle Metropolitan Area**
- **4-County MPO/RTPO**
- **68 Member Jurisdictions**
- **3 Million Population**
- **Top 5 congested metro area (TTI Index)**

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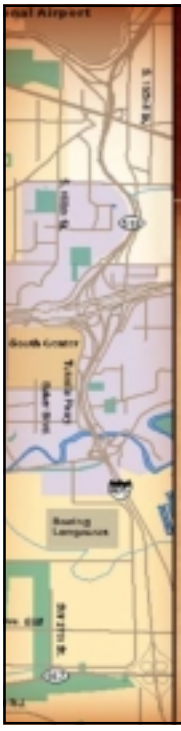

Background

- **Funding**
  - Gasoline Tax
  - Region exports tax revenues to rural areas of State
  - Major loss of highway capital and transit, ferry operating revenue due to public initiative (I-695)
  - Available revenues fall far short of needs
- **Coordination**
  - Projects identified by local jurisdictions
  - Some coordination at “sub-area” level
  - Insufficient coordination of regionally significant facilities
  - Investments are not effectively addressing congestion problems

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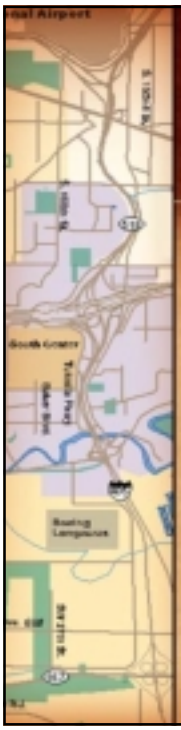

PSRC
Transportation Improvement Program (TIP)

- Receives project submittals from member jurisdictions
- Test projects for consistency with long range (30yr) transportation plan
- Maintains TIP Database
- Administers federal grant programs

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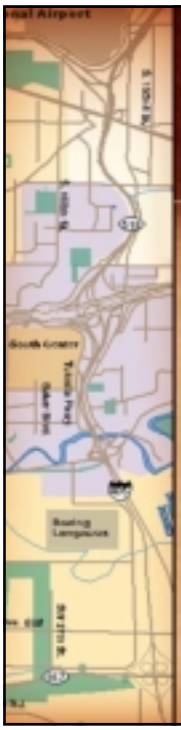

Goal of TIP WebGIS

- Ultimately, to improve the effectiveness by which the region addresses its transportation problem

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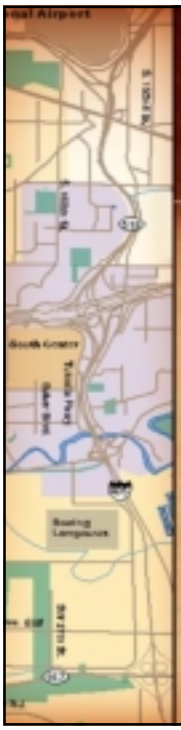

Goals of TIP WebGIS (cont'd)

- **Improve access to TIP information**
  - Add value to information through spatial presentation
  - Reduce demands on staff time
- **Provide better information to project owners**
  - More systematic selection of projects
- **Provide better information to funding authorities**
  - Adequate information to act on priorities

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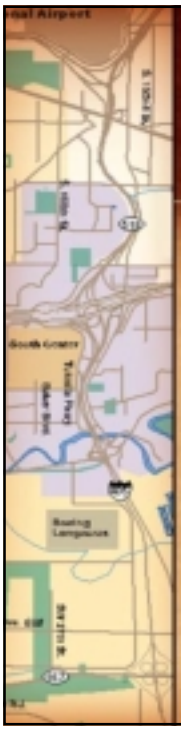

Purpose of WebGIS project

- **Proof of Concept**
  - Determine viability of WebGIS technology for delivery of information
  - Determine scope and resources for full public implementation

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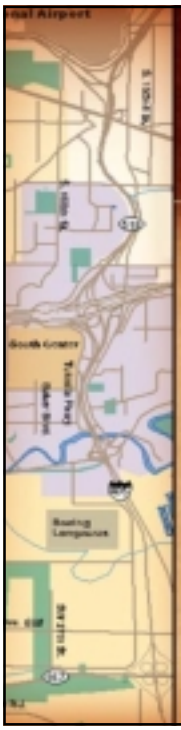

Challenges

- **Schedule / Budget**
- **User Profile / Requirements**
- **Database Management / Connectivity**

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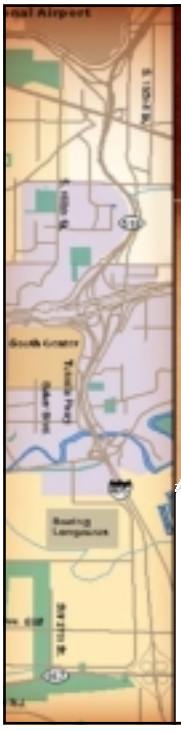

Methodology

- **Software Development Plan**
  - *Construx Software Builders*
    - *Ensure project delivery*
    - *Define process, parameters, and products*
    - *Set and follow monitoring and feedback mechanisms*
    - *Actively confront risks and constraints*
    - *Change control*

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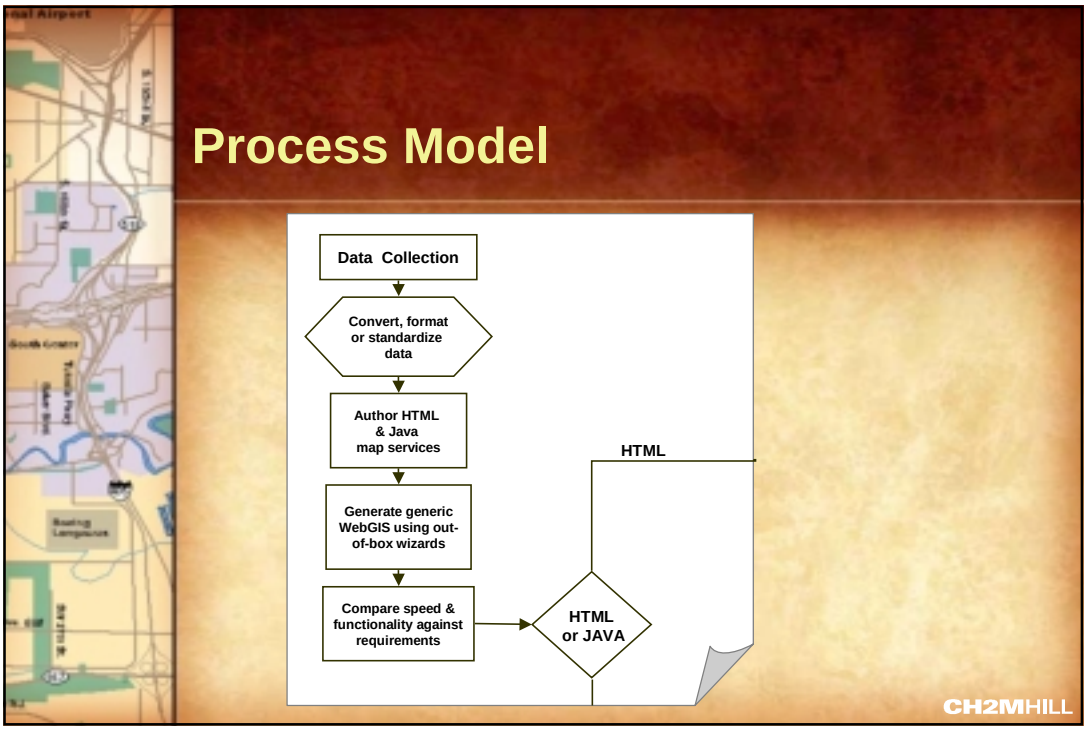
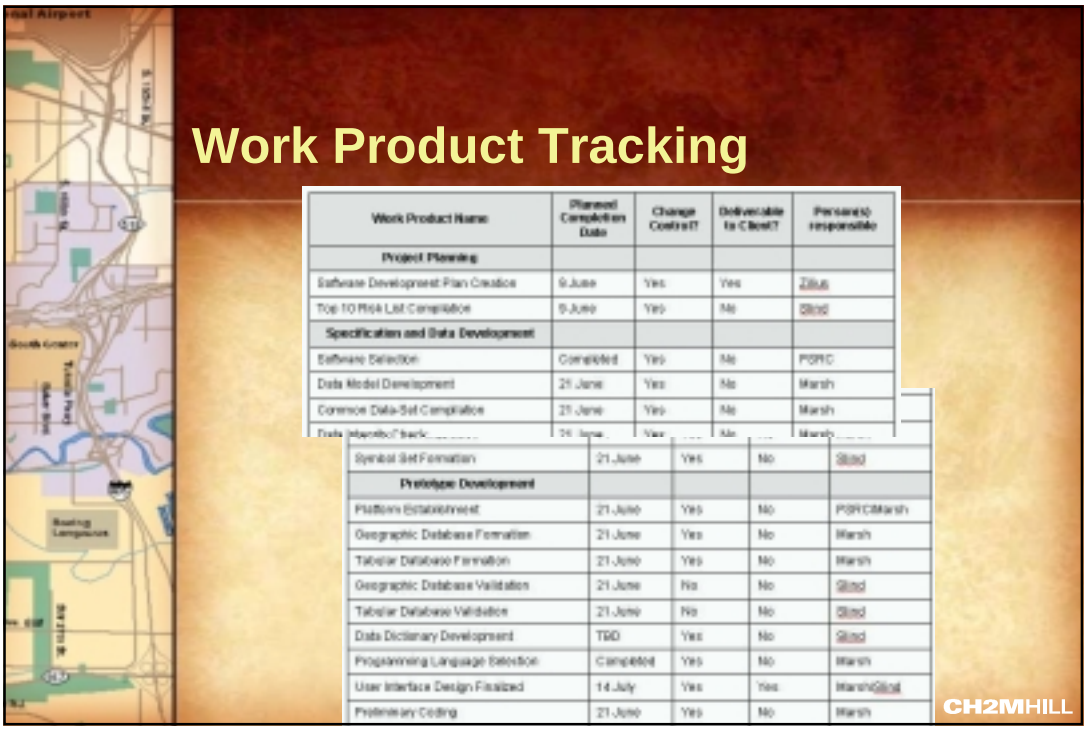
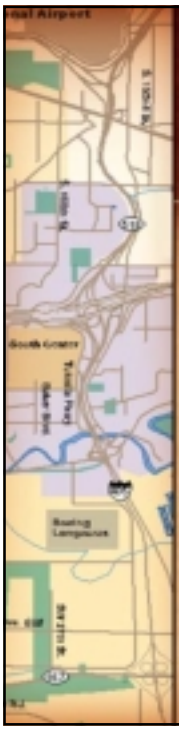




Work Product Name	Planned Completion Date	Change Control?	Deliverable to Client?	Person(s) responsible
Project Planning				
Software Development Plan Creation	9 June	Yes	Yes	Zilius
Top 10 Risk List Compilation	9 June	Yes	No	Slind
Specification and Data Development				
Software Selection	Completed	Yes	No	PSRC
Data Model Development	21 June	Yes	No	Marsh
Common Data-Set Compilation	21 June	Yes	No	Marsh
Symbol Set Formation	21 June	Yes	No	Slind
Prototype Development				
Platform Establishment	21 June	Yes	No	PSRC/Marsh
Geographic Database Formation	21 June	Yes	No	Marsh
Tabular Database Formation	21 June	Yes	No	Marsh
Geographic Database Validation	21 June	No	No	Slind
Tabular Database Validation	21 June	No	No	Slind
Data Dictionary Development	TBD	Yes	No	Slind
Programming Language Selection	Completed	Yes	No	Marsh
User Interface Design Finalized	14 July	Yes	Yes	Marsh/Slind
Preliminary Coding	21 June	Yes	No	Marsh



Risk Management

3.1 Risk Management

Risks to the successful development and delivery of the product within budget and on-schedule:

Rank	Impact	Risk	Risk Resolution Process
1	High	Undefined external demonstration server requirements (hardware spec, licensing)	Work with vendor, IT specialist to resolve
2	Med	Unachievable schedule	Discuss possible alternative schedule w/client. Clear Troy's schedule.
3	Med	New, unproven development platform	Consult vendor support resources, schedule developer consultation
4	Med	Unforeseen technical obstacles encountered in customization	Plan contingencies for each functionality requirement
5	Low	Internal server software not yet obtained	Follow up w/PSRC on status of acquisition

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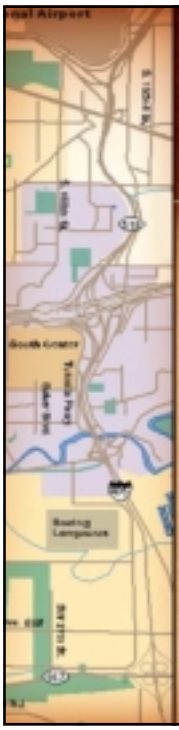

Results

- Project delivered on-time and within budget
- Full functionality provided in accordance with specification
- Highly customized client GUI (HTML, Javascript)
- Database issues deferred to later phase
- Performance and reliability testing completed in January 2001
- Buffering function has problems

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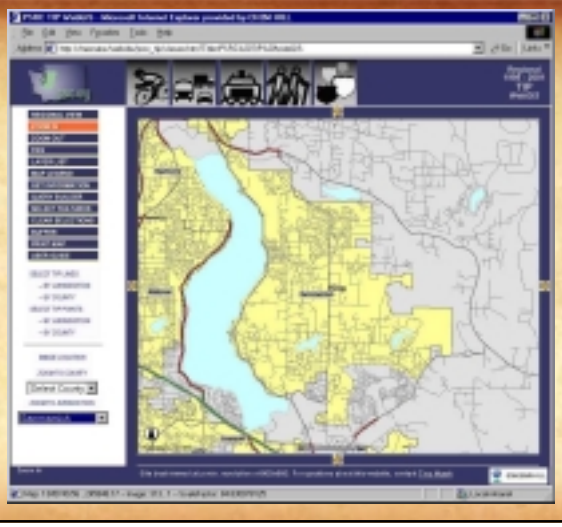
Screen Capture



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Next Steps

- Currently under usability review
- Begin Phase 2 development June 2001
- Public deployment in August 2001

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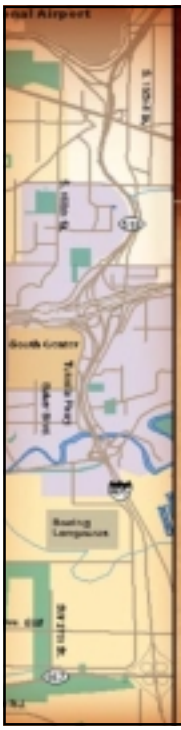

Countywide / Funding Priorities

- **Need to identify projects that provide greatest efficient use of transportation dollars**
- ***KC DOT Hierarchy identifies the facilities of regional significance, coordinated projects along corridors, goal mode splits and performance benchmarks***

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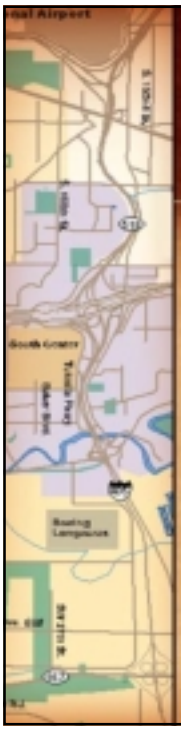

Advantages to this Approach

- **Project level planning and evaluation not multi-modal across jurisdictional boundaries**
- ***Provide tools with uniform multi-modal information for project development and evaluation***

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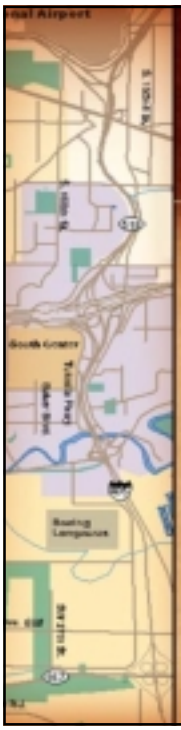

Advantages to this Approach

- **PSRC Model may be too coarse to evaluate benefits of projects regionally significant**
- ***KC DOT performance measures apply to corridors and swaths to help monitor progress and test alternatives***
- ***KC DOT Model is regionally correct with local detail***

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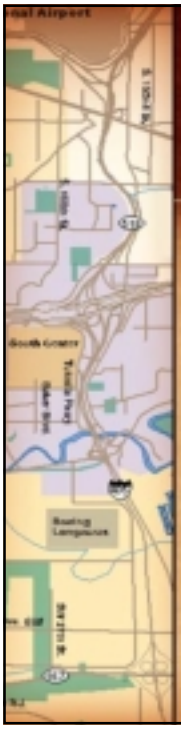

Opportunities to Provide Service

- **Small agencies do not have staff expertise to test and develop multi-modal solutions**
- ***KC DOT TOOLS provides staff time and tools with regional sophistication to help test alternatives***

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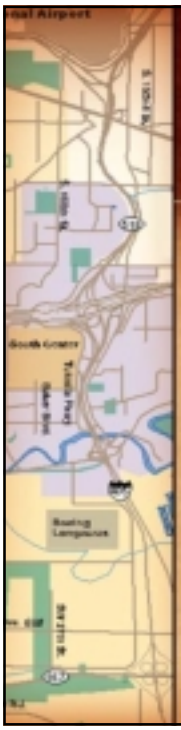

Constituent Issues to Address

- **Local agencies may not want to participate especially if their tools are better**

- ***KC DOT TOOLS will provide maximum benefit to all if most participate***
- ***More sophisticated cities have boundary issues***
- ***Greatest benefit to small agencies with small staff***

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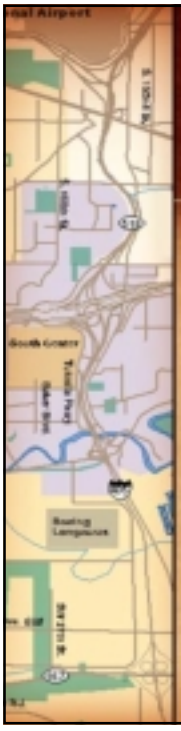

Political Issues to Address

- **Governance Issues**

- ***KC DOT TOOLS and Hierarchy do not challenge agency autonomy and provide a valuable service***

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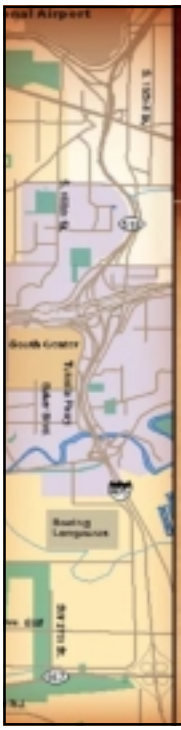

Client Issues to Address

- **Emerging Accountability Requirements**
- ***The Public has acknowledged the need for financing transportation investments, but wants to hold responsible agencies accountable.***

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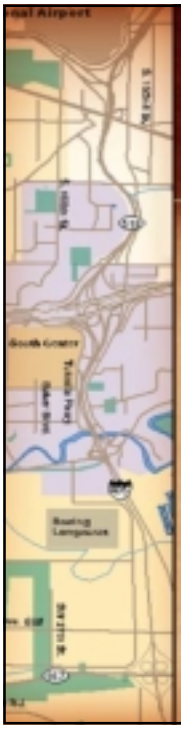

Organizational Issues to Address

- **Distributed resources / ownership**
- ***Capabilities to deliver services reside in separate business units with different missions / goals***

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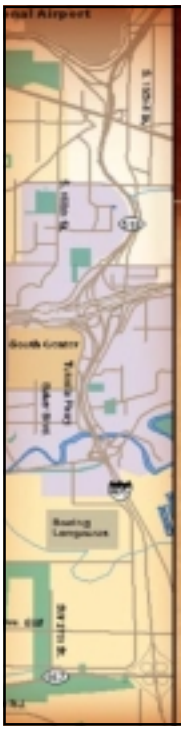

Other Issues to Address

- **External Perceptions**
- ***KC is perceived as a hotbed of technology with a critical mass of resources. Why does a large County with abundant resources NOT have these systems in place?***

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Alameda County Congestion Management Agency (ACCMA)

Integrated Traffic Data and Video Exchange System

Iain McLeman
Technical Project Manager
Jim Tucker, P.E., PMP
Project Manager

Alameda ITDVES

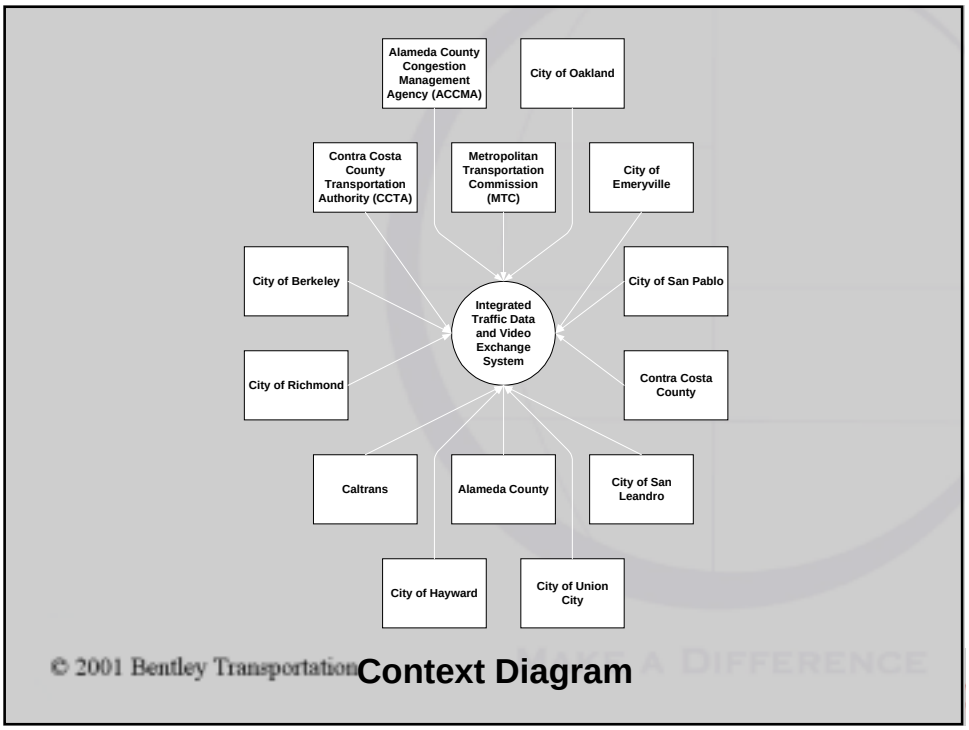
- **Scope**
- **Project Approach**
- **Hardware and Software Architecture**
- **Representative Screen Shots**

ACCMA

- **Congestion management agency**
- **Coordinate transportation planning**
- **Coordinate funding**

Project Scope Statement

- **Develop and implement an integrated system (SW/HW/network) to address electronic exchange of traffic data and video for several transportation management systems in the region**
- **System based on COTS, Bentley ATMS**

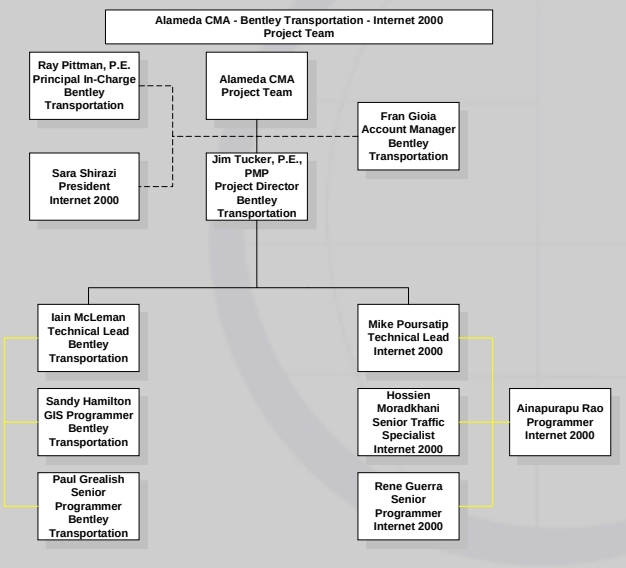


Context Diagram

Project Management Approach (PMI*)

- **Business**
  - Scope
  - Time
  - Cost
  - Quality
  - Resources
  - Communications
  - Risk
  - Procurement
- **Technical**
  - COTS
  - Networks and Protocols
  - Cameras, Kiosks, Message Signs, Ramps, Detectors
  - Traffic Data
  - System Integration
  - WWW

*www.pmi.org

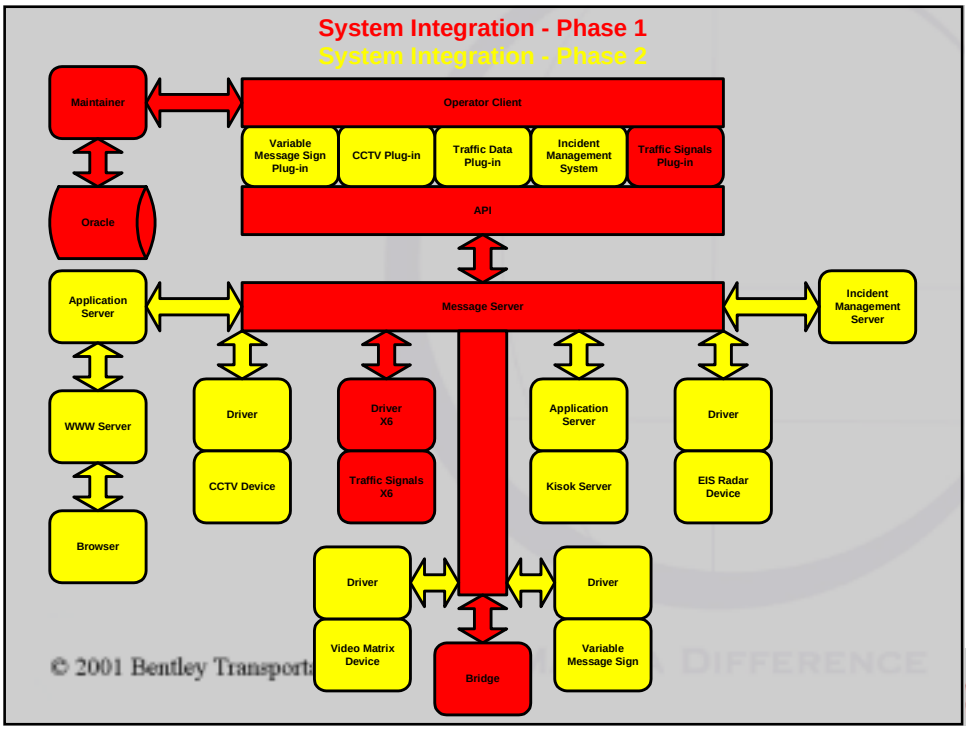


Work Breakdown Structure

- Project Kickoff
- Data Collection
- Detailed Design Concept
- Architecture Design
- Database Design
- Hardware and COTS Implementation
- Application Functions
- Maintenance
- Support
- Post-installation Evaluation

Milestone Deliverables

- Kick-0ff
- Data Collection
- Preliminary Project Review
- Main Project Review
- Critical Project Review 1
- Critical Project Review 2
- San Pablo Installation
- Hesperian Installation
- Project Quality Review

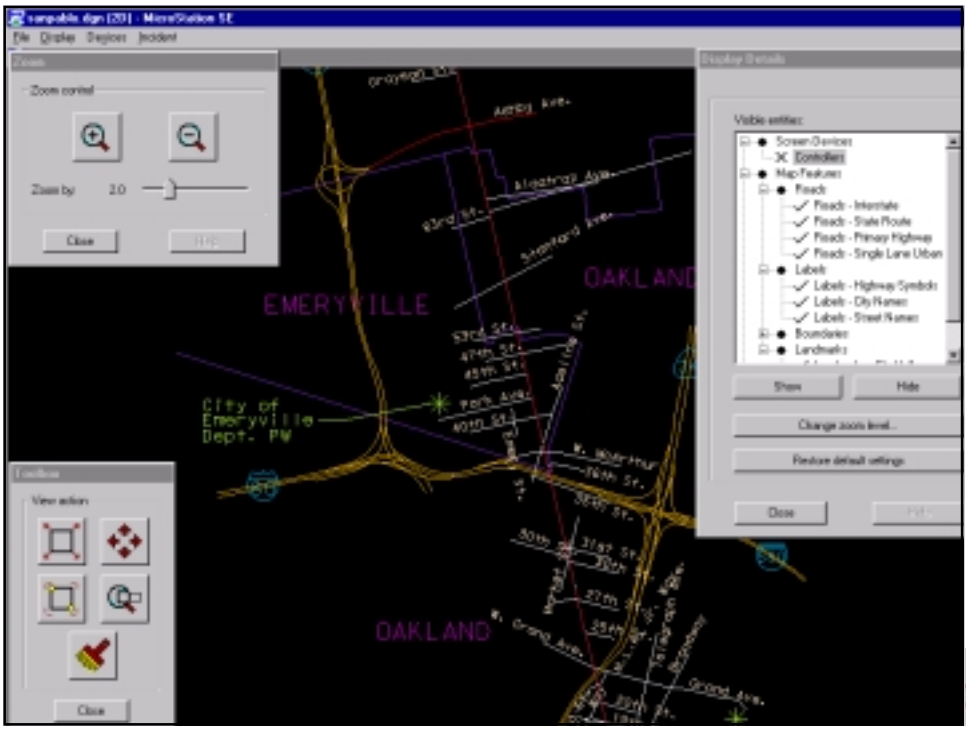


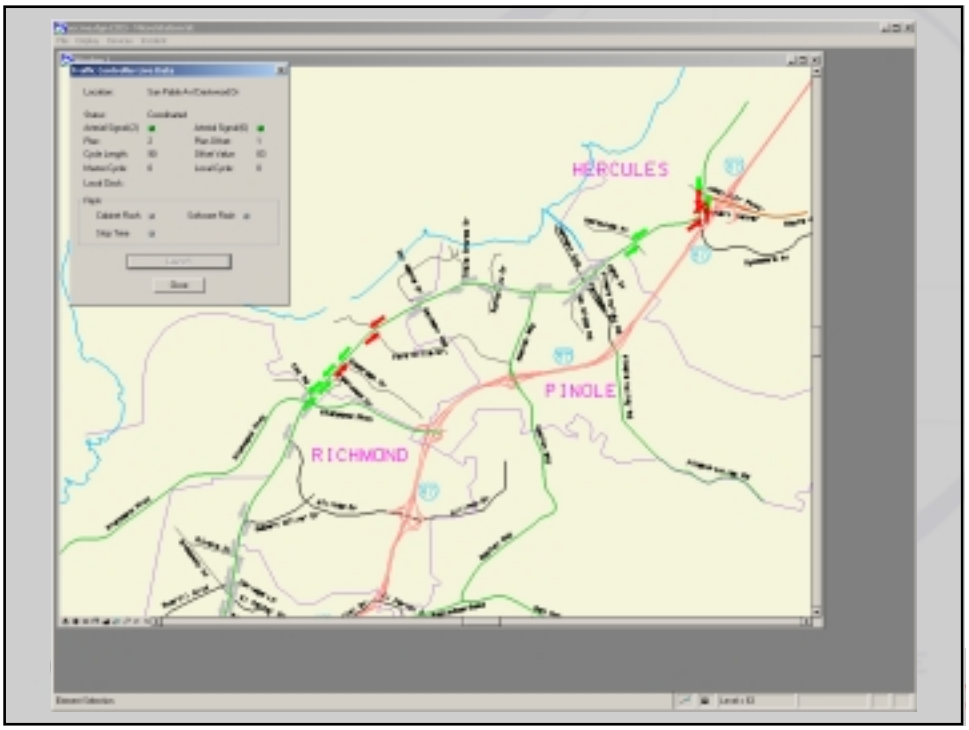
Architecture

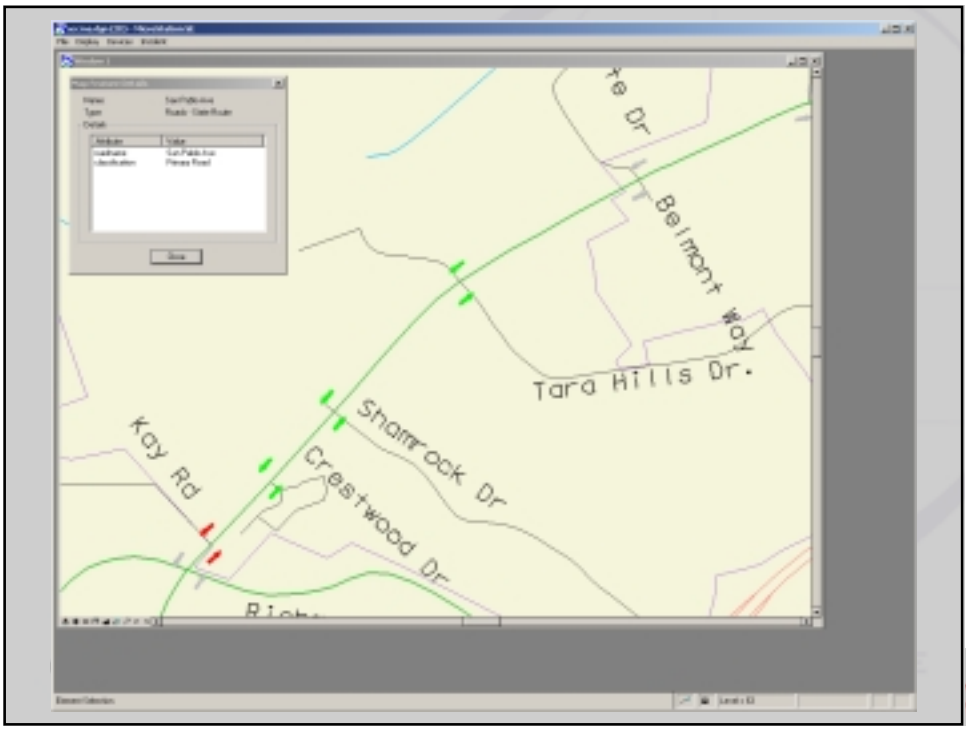
- Intel Pentium processor based Workstations.
- Intel Pentium processor based Servers.
- Microsoft NT/W95/W98 for Workstation/Client
- Microsoft NT Server (Client/Server)
- Field devices

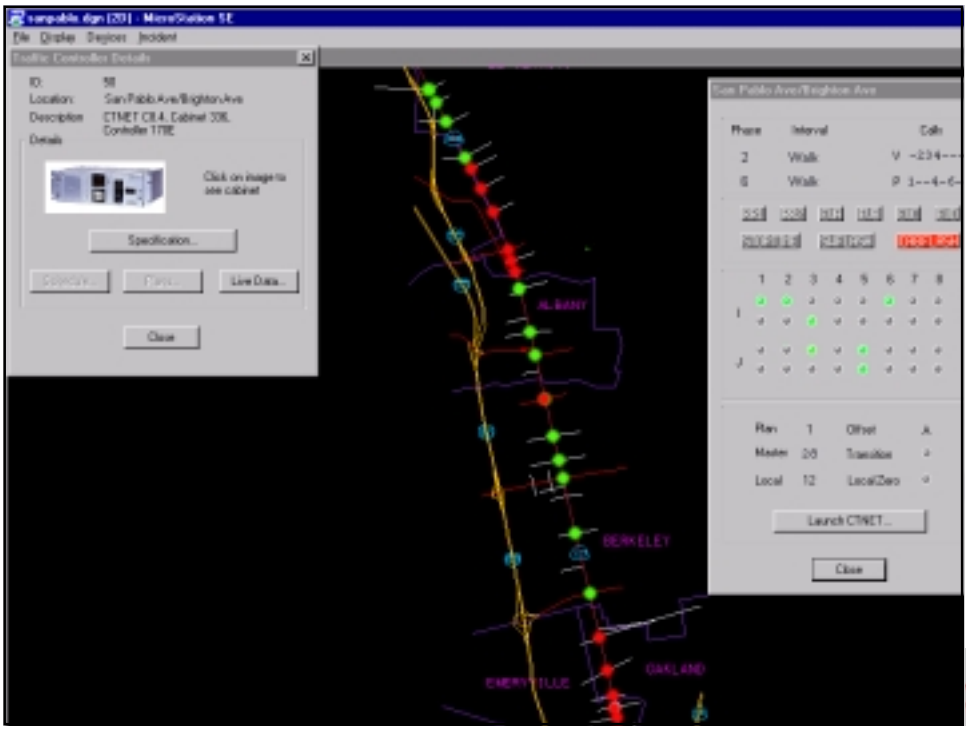
- Oracle RDBMS
- GIS
- Easy to use interface
- Strong vector/Object mapping capability
- Real-time Spatial information display
- TCP/IP
- NTCIP Compliant

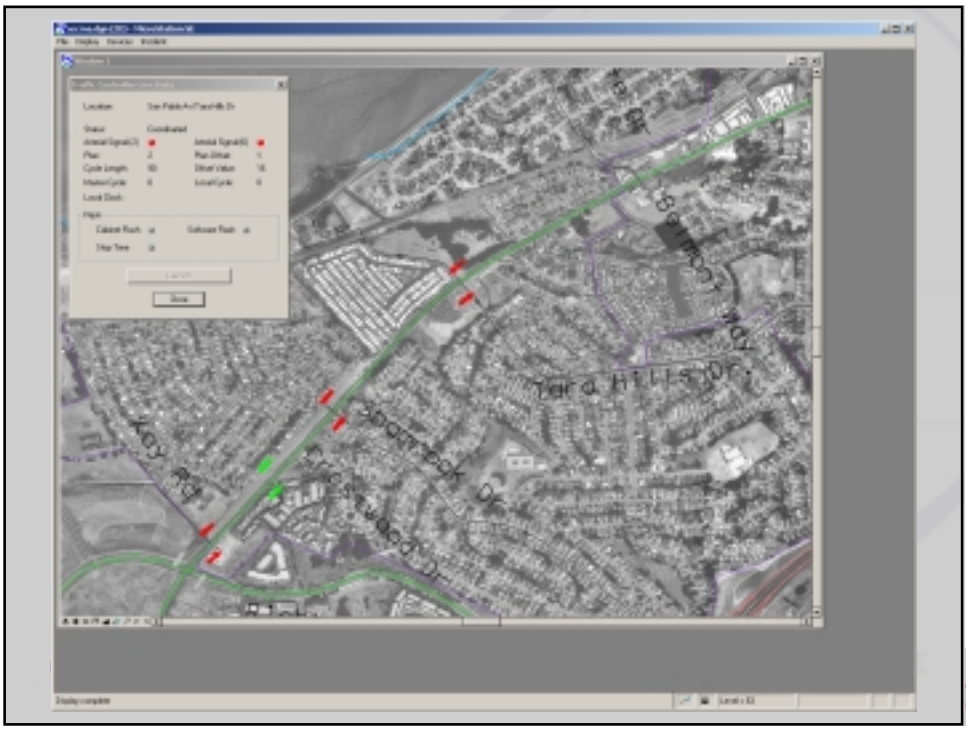
SOFTWARE
- Message Server per CPU
  - 1-10 Clients
  - 11-25 Clients
- Maintainer Seat
- Operator Client
- Web Application Server (view-only)
- Kiosk Client Server
- Incident Management System
- Drivers
  - Traffic Controllers from (pricing per contr
    - CTNET (Caltrans)
    - Quicknet (BiTrans)
    - Aries (Econolite)
    - Icons (Gardner Systems)
    - Naztec
  - Other Traffic Controllers
  - CCTV per Manufacturer
  - Video Matrix per Manufacturer
  - Radar Detector per Manufacturer
  - VMS Driver per Manufacturer
- Developer Toolkit
  - Comprised of Generic Device Drivers,

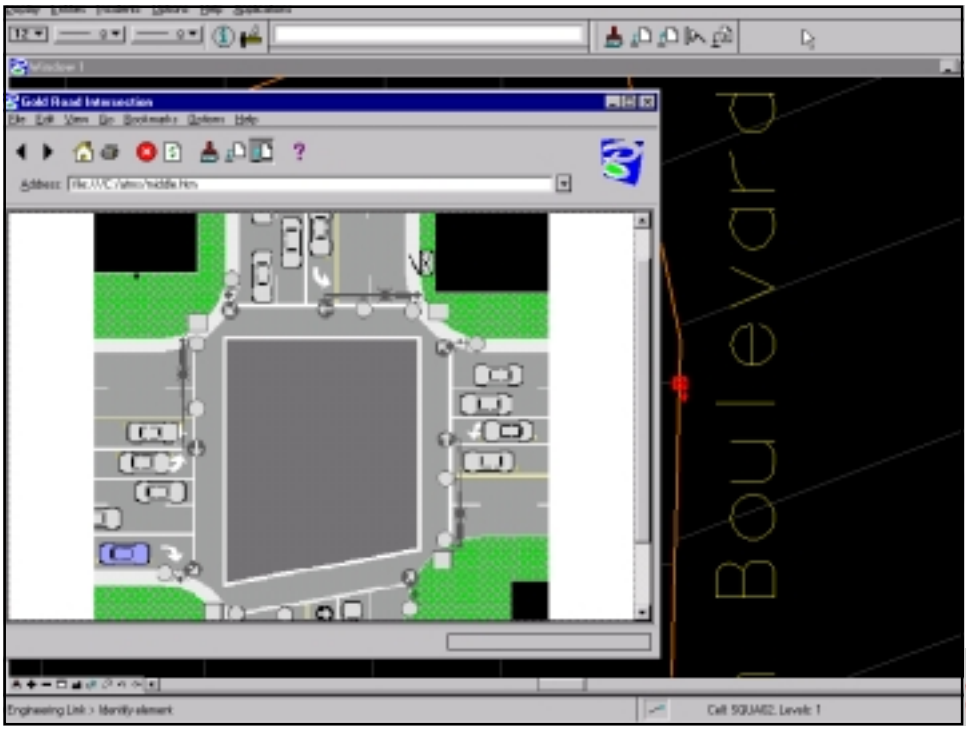

EMERYVILLE
OAKLAND
City of
Emeryville
Dept. PW
OAKLAND


HERCULES
PINOLE
RICHMOND

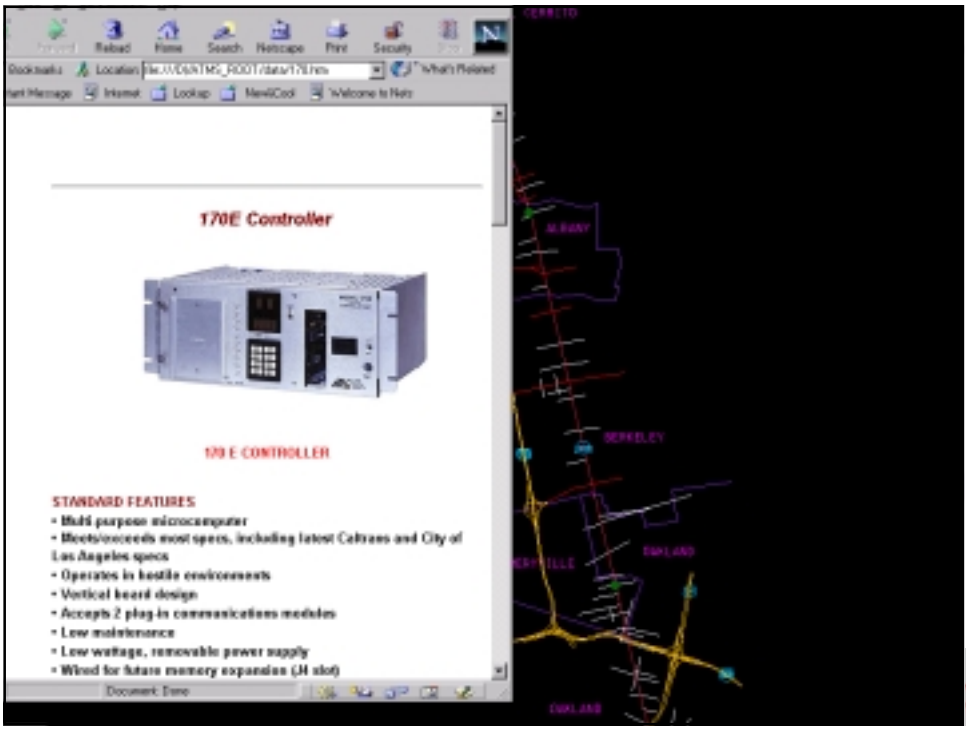

Belmont Way
Tara Hills Dr.
Shamrock Dr
Crestwood Dr
Kay Rd

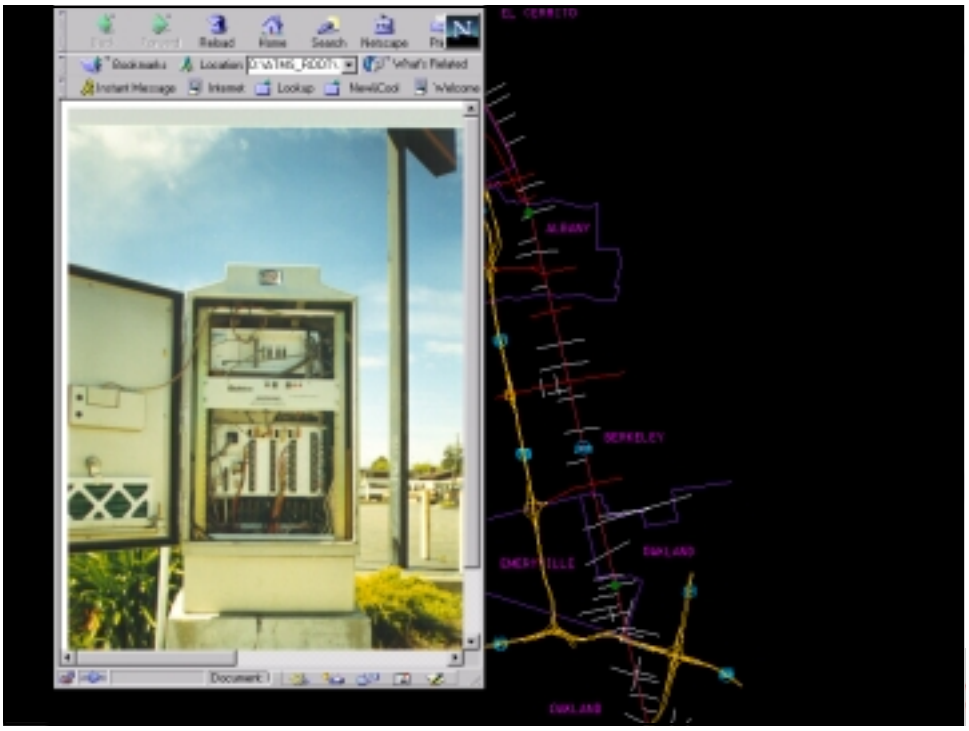

ALBANY
BERKELEY
EMERYVILLE
OAKLAND

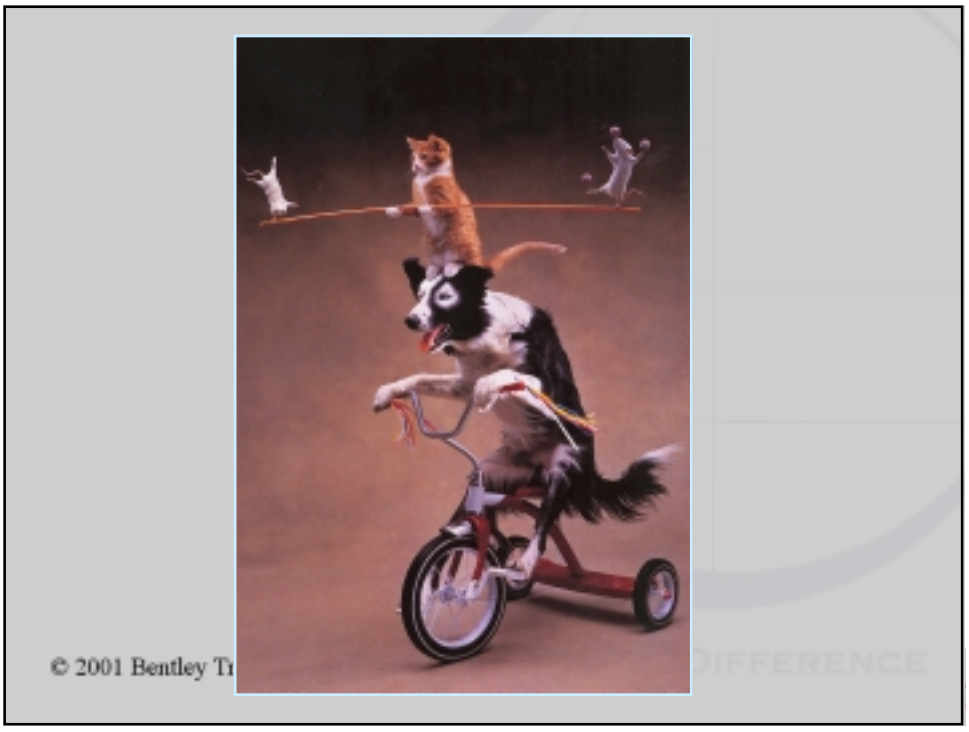

Tara Hills Dr.
Seacliff Dr.
Key Rd.


Gold Road Intersection
Boulevard


ECONOLITE ASC/2 SERIES
NEMA TS1 & TS2 ACTUATED
CONTROLLERS
ASC/2-2100: ASC-8000 interface
The ASC/2-2100, shown at the top of this web page, provides all capabilities of the ASC/2-1000 and -2000, plus an I/O expansion module for compatibility with Econolite's ASC-8000 controller. It adds an Econolite D connector, an Econolite telemetry connector and a NEMA overlap card connector which exactly match those of the ASC-8000. This allows the ASC/2-2100 to be used as a
Boulevard


170E Controller
170 E CONTROLLER
STANDARD FEATURES
• Multi purpose microcomputer
• Meets/exceeds most specs, including latest Caltrans and City of Los Angeles specs
• Operates in hostile environments
• Vertical board design
• Accepts 2 plug-in communications modules
• Low maintenance
• Low wattage, removable power supply
• Wired for future memory expansion (M slot)
BERKELEY
OAKLAND


ALBANY
BERKELEY
EMERYVILLE
OAKLAND


© 2001 Bentley Ti

Summary

- Turnkey solution
- Integrated system (Hardware/Software/Network)
- Off the shelf products
- NTCIP Compliant
- TCP/IP based system
- Intel, NT, Oracle, Bentley ATMS

MAKE A DIFFERENCE

Bentley Transportation

- Business Unit of Bentley Systems, Inc.
- Product Supplier/Systems Integrator
- 47 of 50 Departments of Transportation
- Atlanta ITS
- London Transport

MAKE A DIFFERENCE